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ELECTROMAGNETIC ENVIRONMENT MEASUREMENTS  
OF PRT SYSTEMS AT "TRANSPO<sup>®</sup>72"  
VOLUME IV  
MONOCAB SYSTEM

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JANUARY 1974

FINAL REPORT

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VIRGINIA 22151.

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16. Abstract  An X-Y plot is made of the radiated Electromagnetic signals and noise between 1KHz and 50KHz at each of the four Personalized Rapid Transit (PRT) sites at Dulles International Airport. The PRT systems were operated individually to establish the signal characteristics of each system. A spectrum analyzer was used to view the frequency spectrum broadband prior to recording and a Polaroid scope camera was used in conjunction with the spectrum analyzer to photograph signals between 50KHz and 50MHz. This frequency range was sufficiently broad to cover all command and control frequencies of the four PRT systems.  The purpose of the measurements program was to establish some base line information on the electromagnetic signal characteristics in the Dulles area in the event there was an interaction between the PRT Command and Control systems and the Federal Aviation Administration Air Traffic Control equipment.  The measurements obtained during this series of tests will be used for a comparison with data obtained with no PRT systems operating and later with all four systems operating simultaneously.					
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## PREFACE

The work described in this report was performed as part of a test program conducted to evaluate the Safety and Performance characteristics of the four Personalized Rapid Transit Systems (PRT) on display at Transpo<sup>®</sup> 72. Sponsored by the U.S. Department of Transportation, Transpo<sup>®</sup> 72 was the first United States International Transportation Exposition and was intended to demonstrate to the general public new technologies in transportation.

The PRT demonstration program was the responsibility of the Urban Mass Transportation Administration (UMTA) and was conducted to provide detailed engineering test data in addition to providing mature candidates for an Urban demonstration.



## RADIATED FIELD NOISE MEASUREMENTS

### MONOCAB SYSTEM - TRANSPO<sup>®</sup>'72

#### 1. INTRODUCTION

This technical report presents the data obtained in the performance of tests for radiated field noise at the personal rapid transit (PRT) system of MONOCAB at TRANSPO<sup>®</sup>'72 - Dulles Airport, Washington, D.C. This report covers one of the four tests defined under Item 2 of Contract DOT-TSC-375, and as performed by National Scientific Laboratories.

Item 2 calls for the performance of radiated field noise measurements from each PRT system in the frequency range from 1 KHz to at least 50 MHz with one PRT system on. The objective of the test was to gather operational data for each of the PRT systems. Such data will enable characterization of the noise increase attributable to system operation, when considered in comparison with the ambient data collected and documented\* previously by NSL.

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\* Technical Report, Item 1, Ambient Radiated Field Noise Survey, PRT Systems - TRANSPO<sup>®</sup>'72, March 1972, Contract DOT-TSC-375, Department of Transportation, Transportation Systems Center, 55 Broadway, Cambridge, Massachusetts 02142

## 2. METHOD OF MEASUREMENT

All measurements were made using test setups and instruments as nearly identical as possible to those used during ambient testing.

### 2.1 Instruments

The measurements made in the frequency range from 1 KHz to 50 KHz were performed using a Fairchild Model EMC-10 Interference Analyzer. This device is a battery-operated calibrated RFI/EMI meter, which, when operated as a narrowband tunable device, covers the frequency range from 1 KHz to 50 KHz. The receiver incorporates a meter circuit of such design that signal levels are expressed in decibels on a linear scale. In addition, the receiver incorporates circuitry providing buffered voltage outputs in proportion to meter indication and tuned frequency. A Hewlett Packard Model 3005B X-Y Plotter was driven from the receiver.

Signals were obtained from the electro-magnetic environment by use of either a Fairchild PEF-10 Electric Field Antenna or a Fairchild ALP-10 Magnetic Field Antenna. Both of these antennas are directional in the horizontal plane, therefore, measurements were made for North/South and East/West orientations.

The measurements made in the 50 KHz to 60 MHz frequency range were performed using a Hewlett Packard Model 8552/8553A Spectrum Analyzer. The analyzer is an extremely versatile



instrument in that it has numerous frequency scan and bandwidth settings through the frequency spectrum of a few cycles up to 100 MHz. The analyzer was used in four frequency bands - 50 KHz to 100 KHz, 100 KHz to 1.1 MHz, 1 MHz to 21 MHz, and 10 MHz to 60 MHz. Data was recorded photographically with a Hewlett Packard Model 198A oscilloscope camera.

Signals were obtained from the electro-magnetic environment in the 50 KHz to 21 MHz frequency range by using an NSL verticle top loaded whip electric field antenna mounted on a Cathode follower. This antenna is non-directional in the horizontal plane. In the 20 MHz to 60 MHz frequency range, an EMCO Model 3104 biconical electric field antenna was utilized. This antenna is directional in the horizontal plane, therefore, measurements were made in the North/South and East/West orientations.

During the tests, the various antennas were attached to the top of a mast mounted on the NSL instrumentation van. An antenna rotator was incorporated in the antenna mast to enable rotation in azimuth. The antenna height was approximately 12 feet above ground.

The various instruments received ac power from a motor generator positioned 150 feet from the van.

## 2.2 Test Sites

The test sites used during the performance of the measurements were the same locations as denoted in the Item 1 report for the ambient noise tests. The sites are numbered 1 through 11 for the entire PRT area. Sites 6, 7 and 8 are located at the

MONOCAB system as shown in the map, Figure 1. A complete set of measurements was obtained at each site - magnetic field, 1 KHz to 50 KHz and electric field, 1 KHz to 60 MHz.


### 2.3 Measurement Technique

Data were obtained in the 1 KHz to 50 KHz frequency range by scanning manually the EMC-10 receiver, using a 50 Hz bandwidth setting. Two recordings have been made for each antenna (magnetic field, electric field) in two orientations (North/South, East/West). The scanning time per recording averaged four to six minutes.

The magnetic field recordings, denoted as MSR type test on the charts, are reproduced in the Appendix as the upper half of pages A-2 to A-5, A-15 to A-18, and A-28 to A-31. The dB scale refers to the level at the instruments input connector. Some of the charts have two amplitude scales. Located somewhere along the bottom of the chart is an upside down letter "Y" which denotes the point of changeover from the scale on the left side to the scale on the right side. The lower chart on each page is a plot of approximately one level in each major frequency increment of the chart directly above it. Peaks were selected whenever available. A correction factor for the antenna (antenna amplitude response is non-linear with frequency) has been included in the levels plotted in the lower graphs. In the upper charts, noise peaks recorded in the top major amplitude division are out of the calibrated range of the instrumentation system. Thus, the levels plotted for peaks that

LEGEND

- |    |                    |    |                               |    |                 |
|----|--------------------|----|-------------------------------|----|-----------------|
| 1  | Parking Area 1     | 11 | Exhibit Pavilion              | 21 | Terminal        |
| 2  | Parking Area 2     | 12 | Personal Rapid Transit System | 22 | Office Building |
| 3  | Parking Area 3     | 13 |                               | 23 | Hotel           |
| 4  | Parking Area 4     | 14 |                               | 24 | Lake            |
| 5  |                    | 15 |                               |    |                 |
| 6  | Parking Area 6     | 16 | Water Related Exhibits        |    |                 |
| 7  | Parking Area 7     | 17 |                               |    |                 |
| 8  | Parking Area 8     | 18 |                               |    |                 |
| 9  | Main Entrance      | 19 |                               |    |                 |
| 10 | Exhibitor Entrance | 20 |                               |    |                 |

TEST SITE NO. 

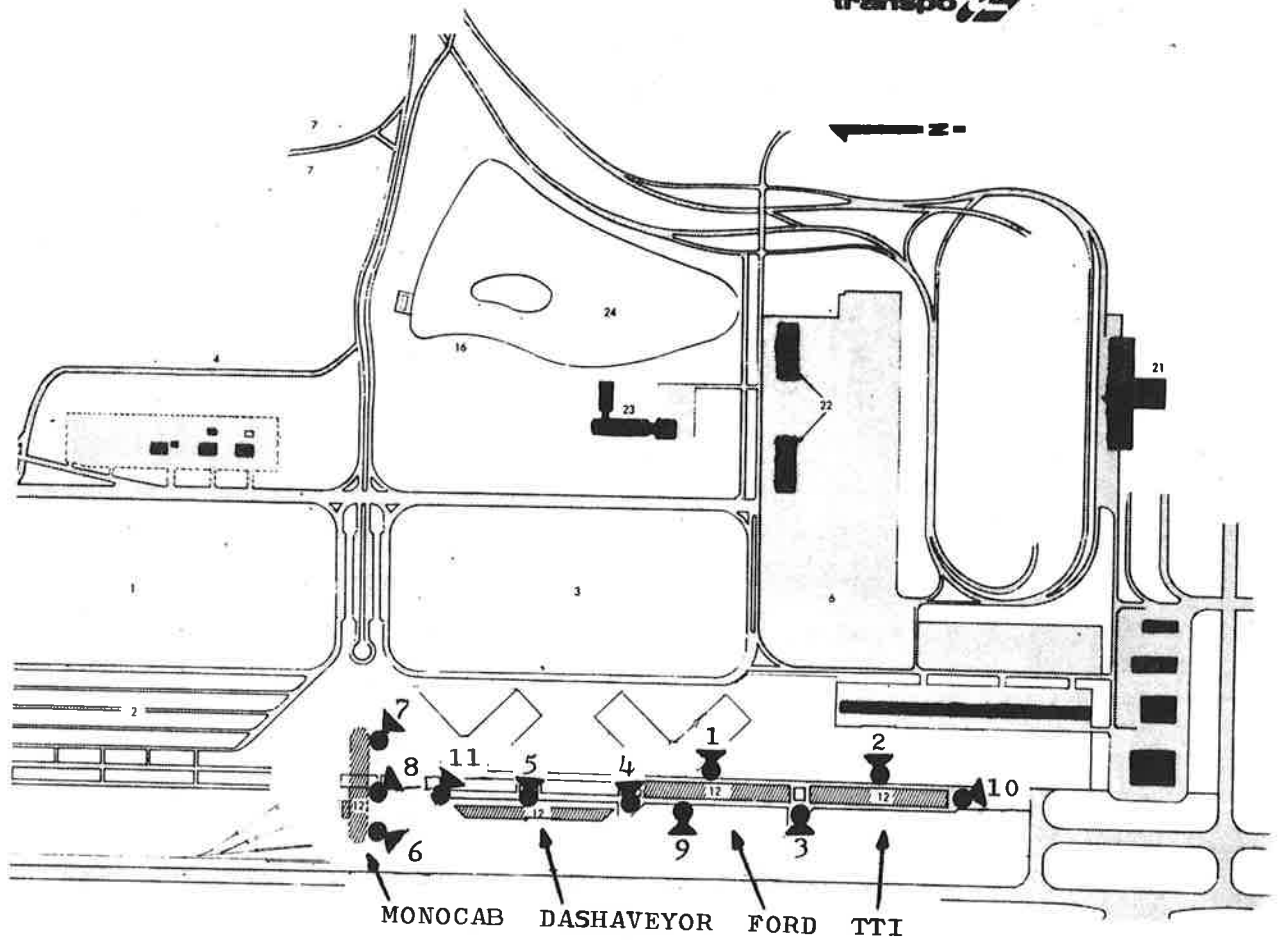


FIGURE 1. PRT TEST SITE LOCATIONS

enter the upper division are plotted as having an amplitude of the highest level indicated numerically on the chart for that particular frequency.

The electric field chart recordings, denoted as ESR type test on the charts, are reproduced in the Appendix on pages A-6 to A-9, A-19 to A-22, and A-32 to A-36. Some of these charts also have two amplitude scales, and they are used in the same manner as described for the magnetic field recordings. In addition, noise peaks recorded in the top major amplitude divisions are out of the calibrated range of the system. The antenna employed has a constant correction factor for all frequencies, and it has been included in the scale designations on these charts.

Electric field data for the 50 KHz to 60 MHz frequency range were obtained as photographic recordings of spectrum analyzer amplitude/frequency CRT displays. Two recordings have been made for each frequency band - 50 KHz to 100 KHz, 100 KHz to 1.1 MHz, and 1 MHz to 21 MHz. A non-directional antenna was used for the above frequencies. Four recordings were obtained for the 10 MHz to 60 MHz frequency band for which a directional antenna was employed, therefore, two recordings were made for North/South orientation and two recordings for East/West orientation. The antenna employed for the first three frequency bands has a constant correction factor for all frequencies, and this is included in the amplitude designations for the recorded

data. The antenna employed for the high frequency band has a nearly constant correction factor above 20 MHz and this factor has been included in the amplitude designations for the recorded data. Thus, the calibration levels given by the side of the photograph do not apply to frequencies from 10-20 MHz. The photographic recordings are reproduced in the Appendix on pages A-10 to A-14, A-23 to A-27, and A-37 to A-41.

### 3. INTERPRETATION OF DATA

Radiated signals have been measured at three sites in the area of the MONOCAB installation. These data are contained in the appendix. Notations are on some of the charts wherein we were able to identify vehicle function occurring simultaneously with signals. In other instances, no correlation was apparent.

### 4. TIME LOG

The time log of events for MONOCAB vehicle operations is contained on Pages A-42 and A-43 of the Appendix. The measurements reported in this document were made during the forenoon of July 26, 1972, and late afternoon on July 28, 1972.



APPENDIX A

RADIATED FIELD MEASUREMENTS DATA

This appendix contains the data obtained during the various tests performed. The data is not presented in numerical sequence as the tests were performed, but rather by site location number from east to west - Site No. 7, 8, and 6. Further, the data are arranged in the following manner - first, magnetic field charts, then electric-field charts and photographs in order of frequency progression. Data is contained herein for Test No's. 192 to 220 (less 197) and 323 to 334.

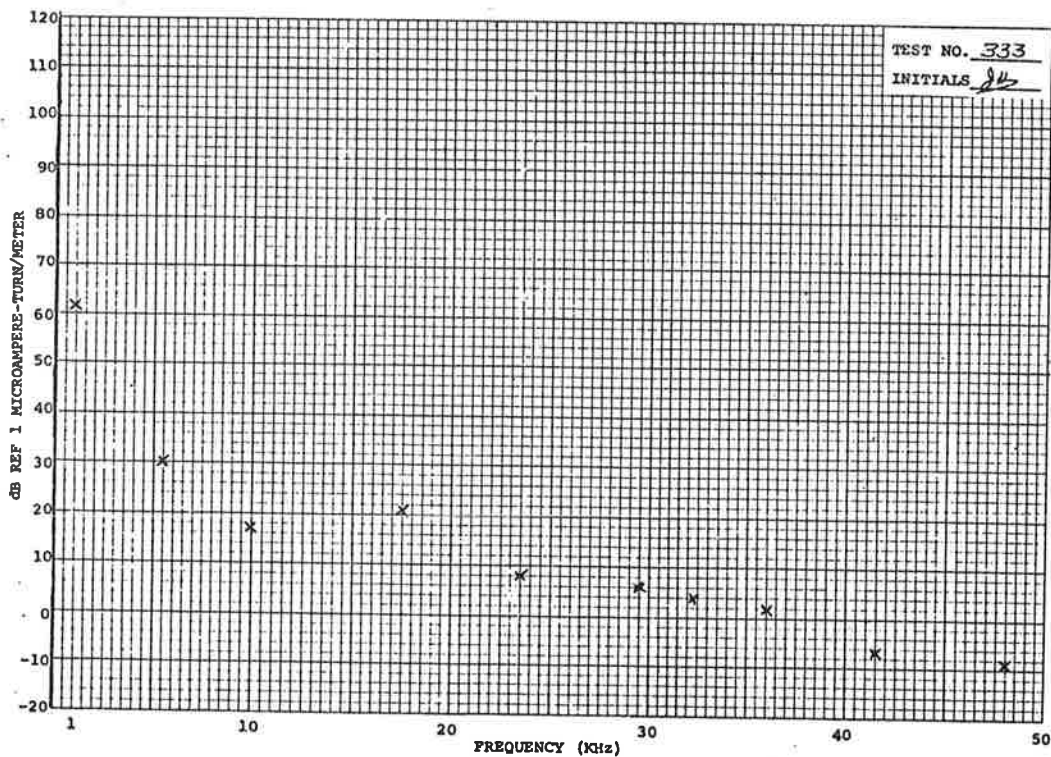
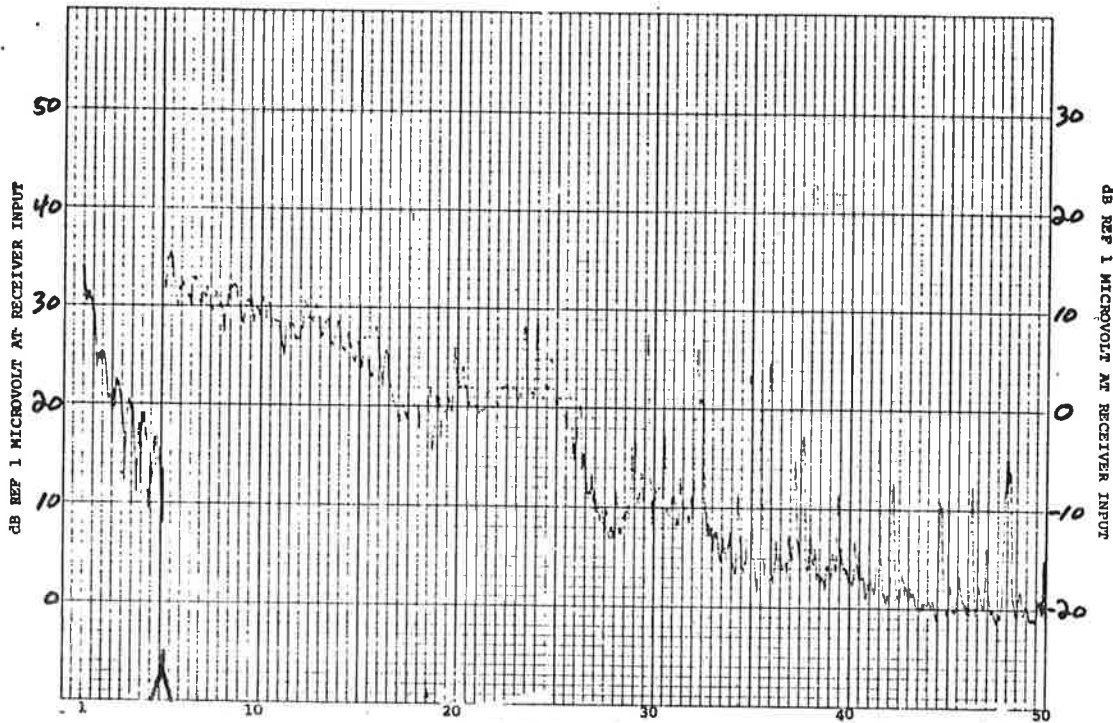
A time log of events for PRT vehicle operations is contained on pages A-42 and A-43.

TEST NO. 333  
TEST SPECIMEN 847

TEST TYPE MSC EW  
TEST EQUIP. ENG-10

BANDWIDTH 50Hz  
DATE 7-28-72

1554  
*[Signature]*



TEST NO. 333  
INITIALS JB

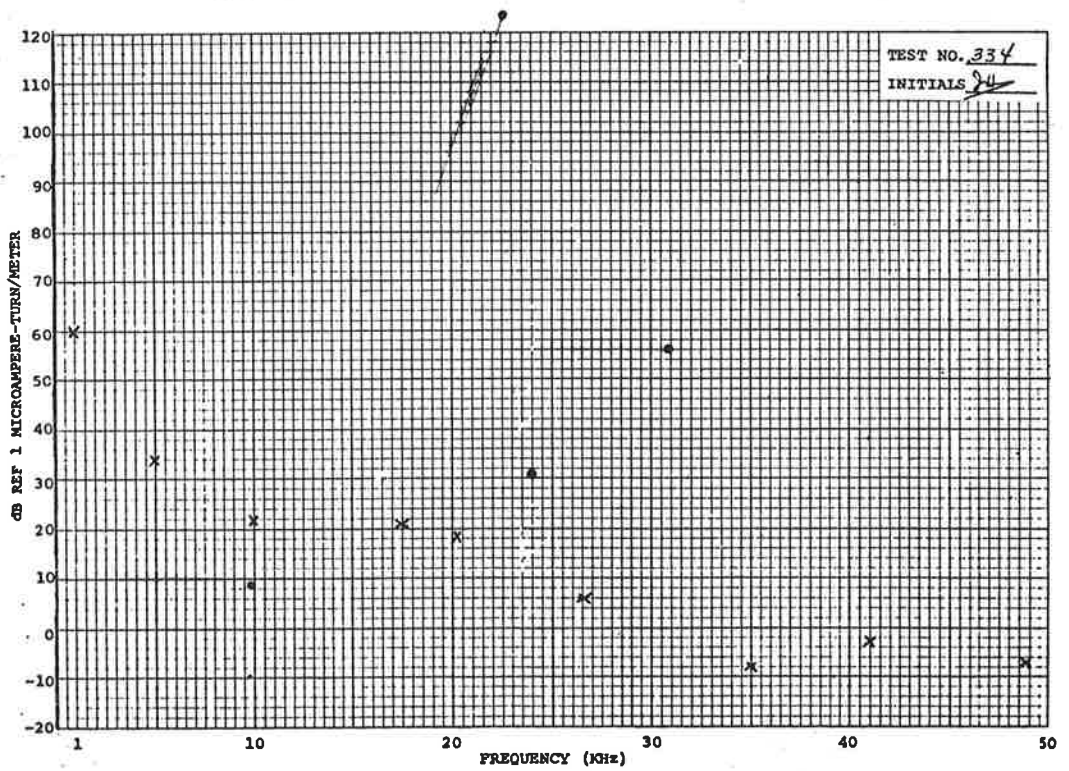
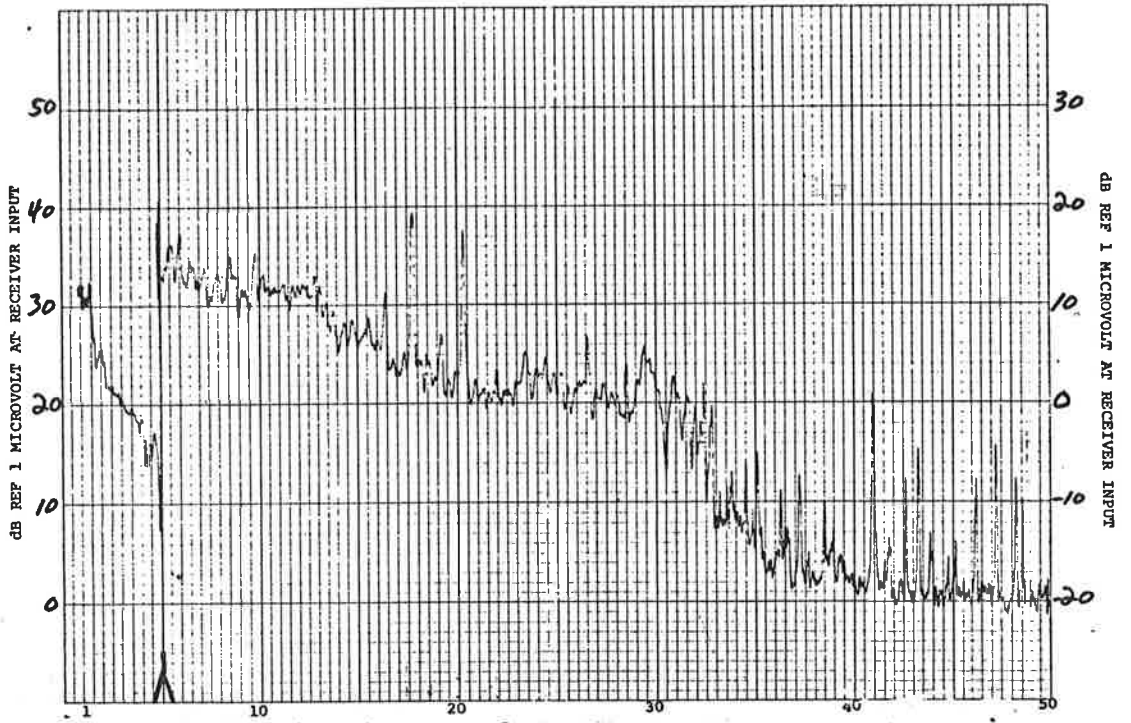


TEST NO. 334  
TEST SPECIMEN 8.67

TEST TYPE MSR F/W  
TEST EQUIP. EMC-10

BANDWIDTH 50Hz  
DATE 7-28-72

1605  
EJ



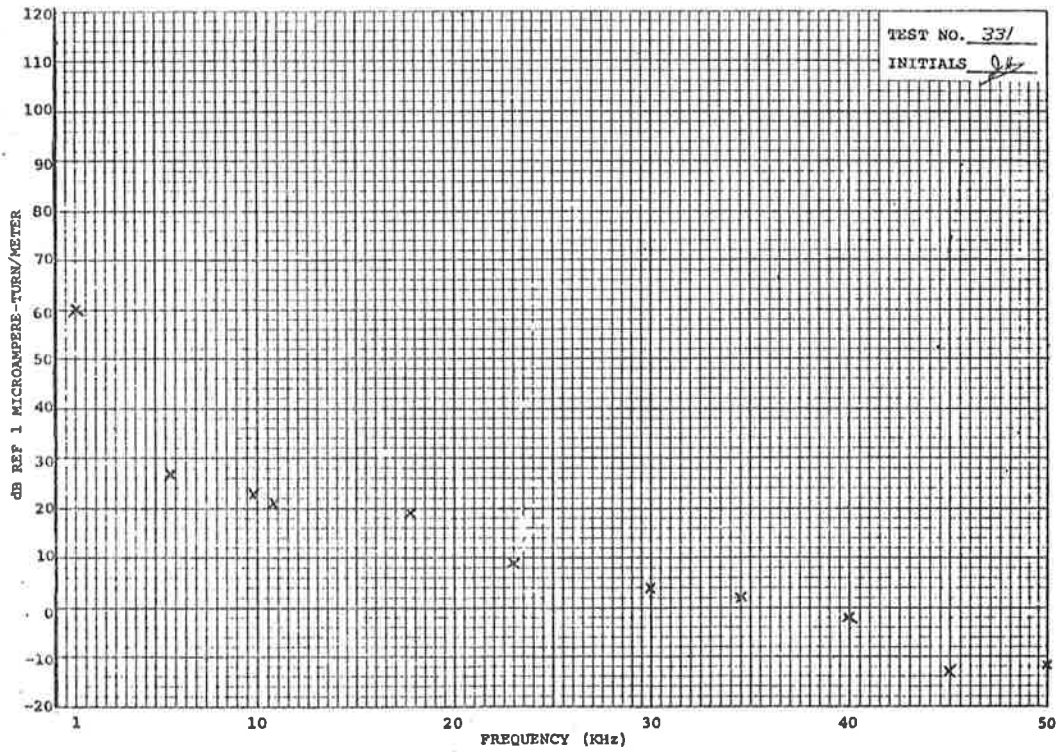
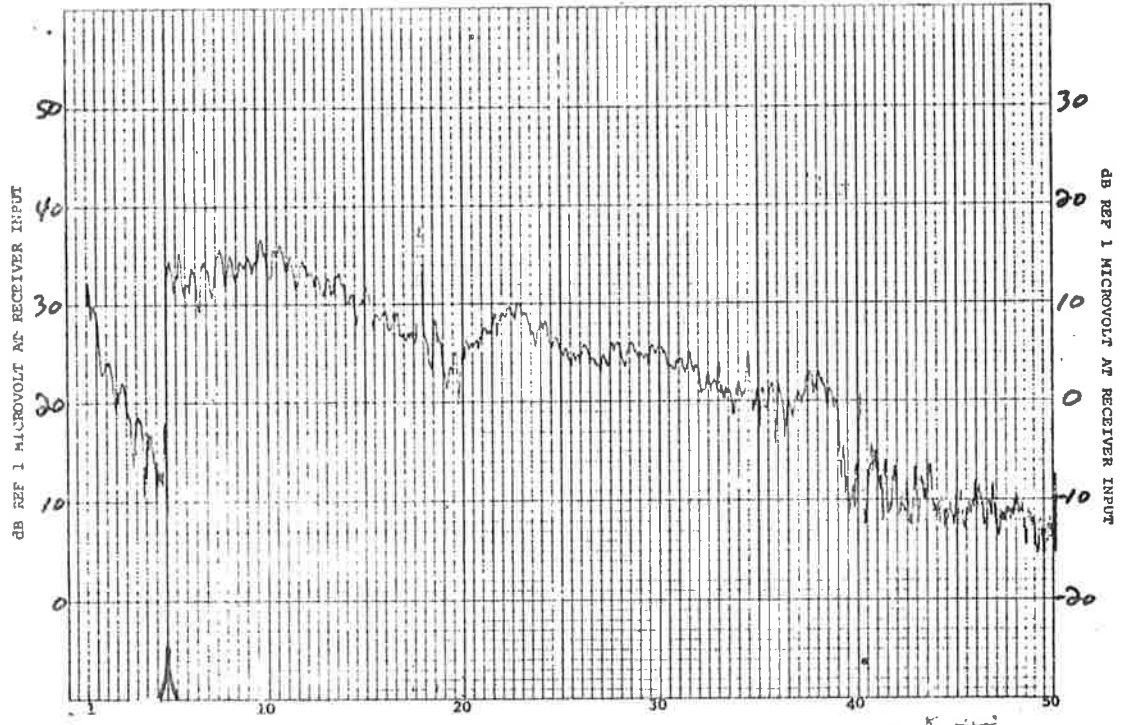
TEST NO. 334  
INITIALS EJ

TEST NO. 331  
TEST SPECIMEN 8361

TEST TYPE MSR N/S  
TEST EQUIP. FMC-10

BANDWIDTH 50 Hz  
DATE 1-28-72

1547  
SS



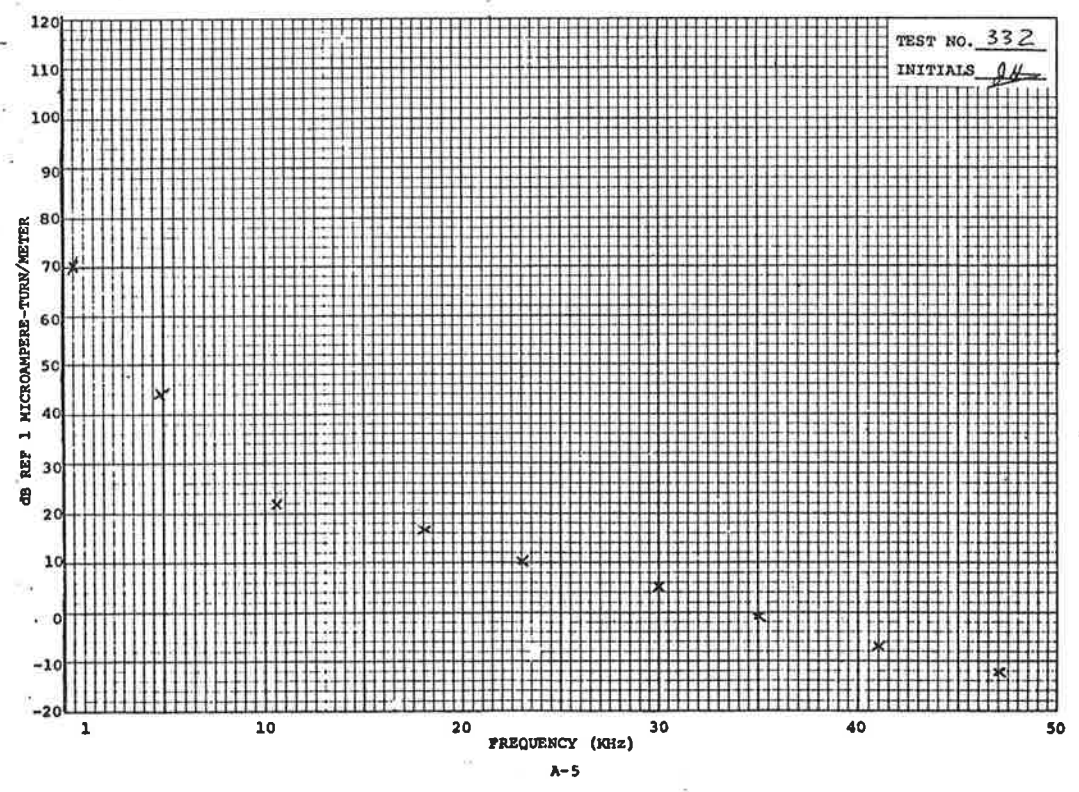
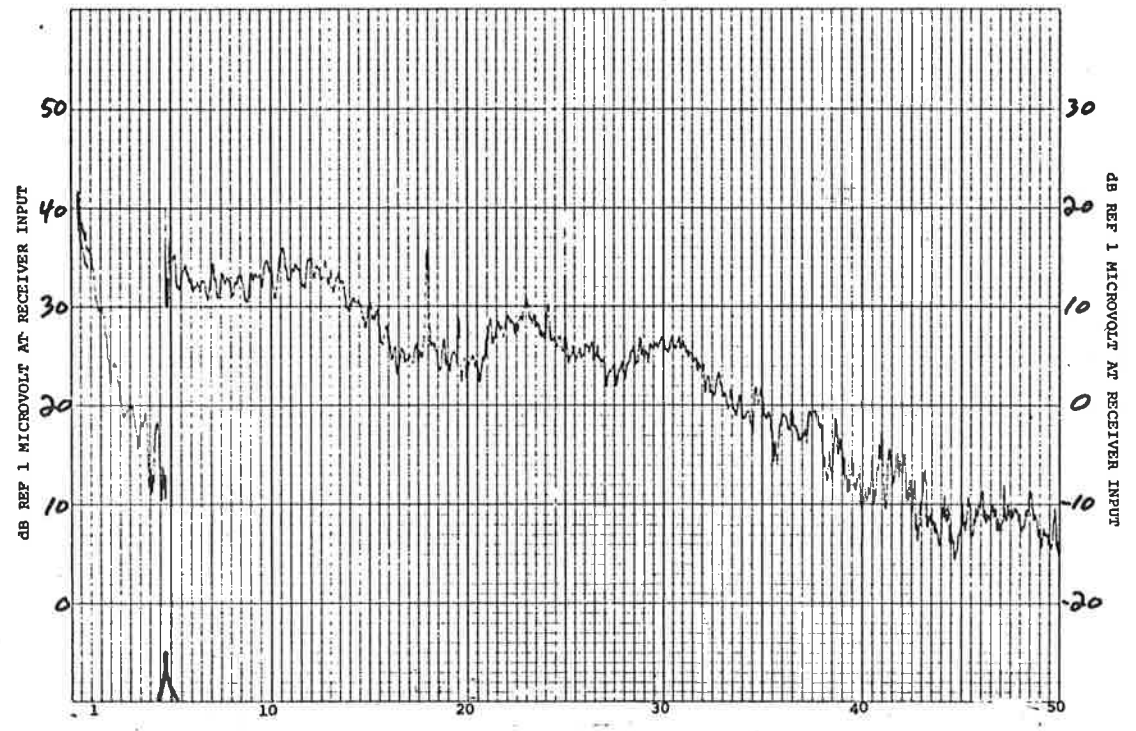
TEST NO. 331  
INITIALS SS

TEST NO. 332  
TEST SPECIMEN 8.67

TEST TYPE MSR N/S  
TEST EQUIP. EMC-10

BANDWIDTH 50Hz  
DATE 7-28-72

1550  
889

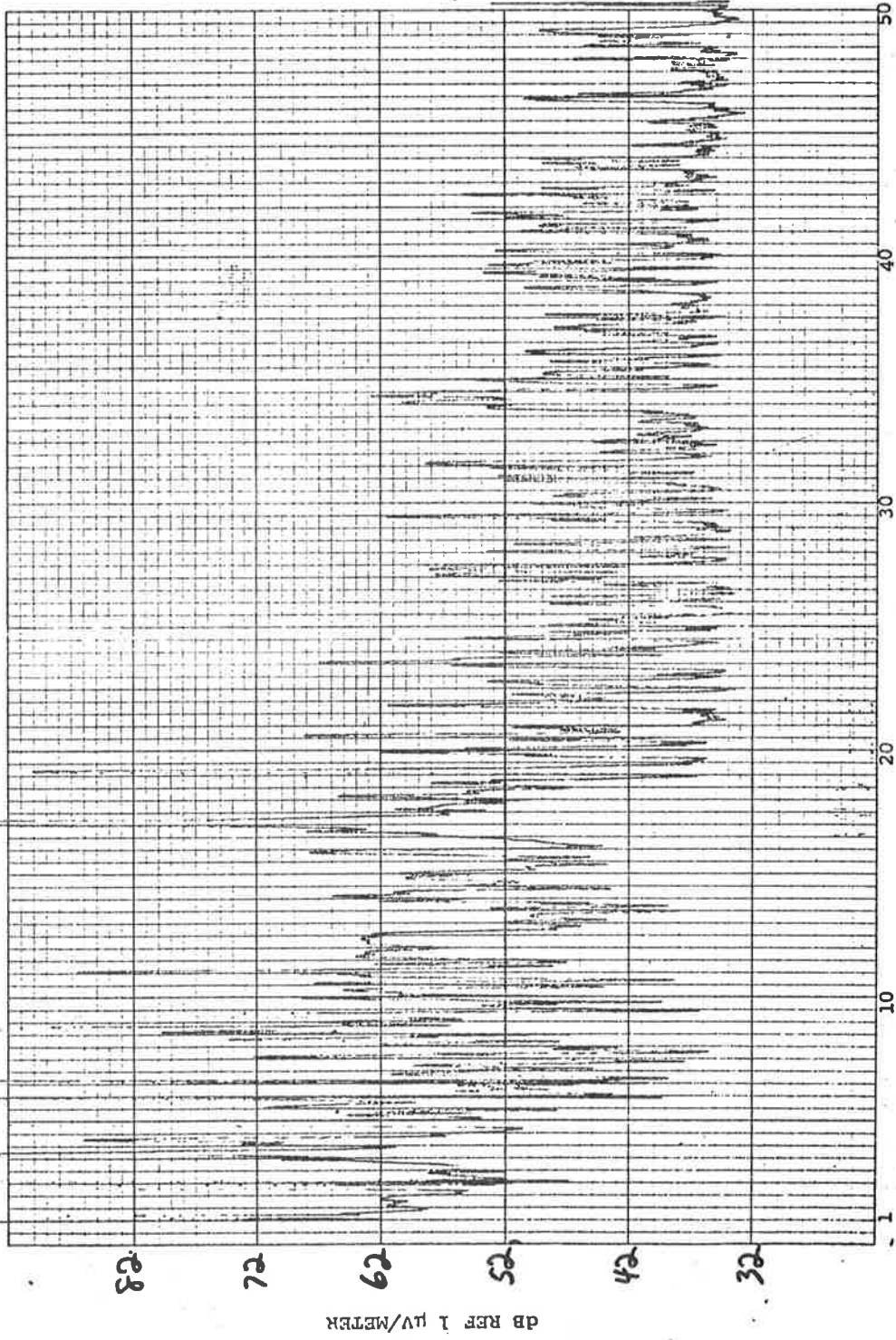


1035  
URC

BANDWIDTH 50Hz  
DATE 7-26-72

TEST TYPE ESR E/W  
TEST EQUIP. EMC-10

TEST NO. 203  
TEST SPECIMEN 267



dB REF 1 μV/METER

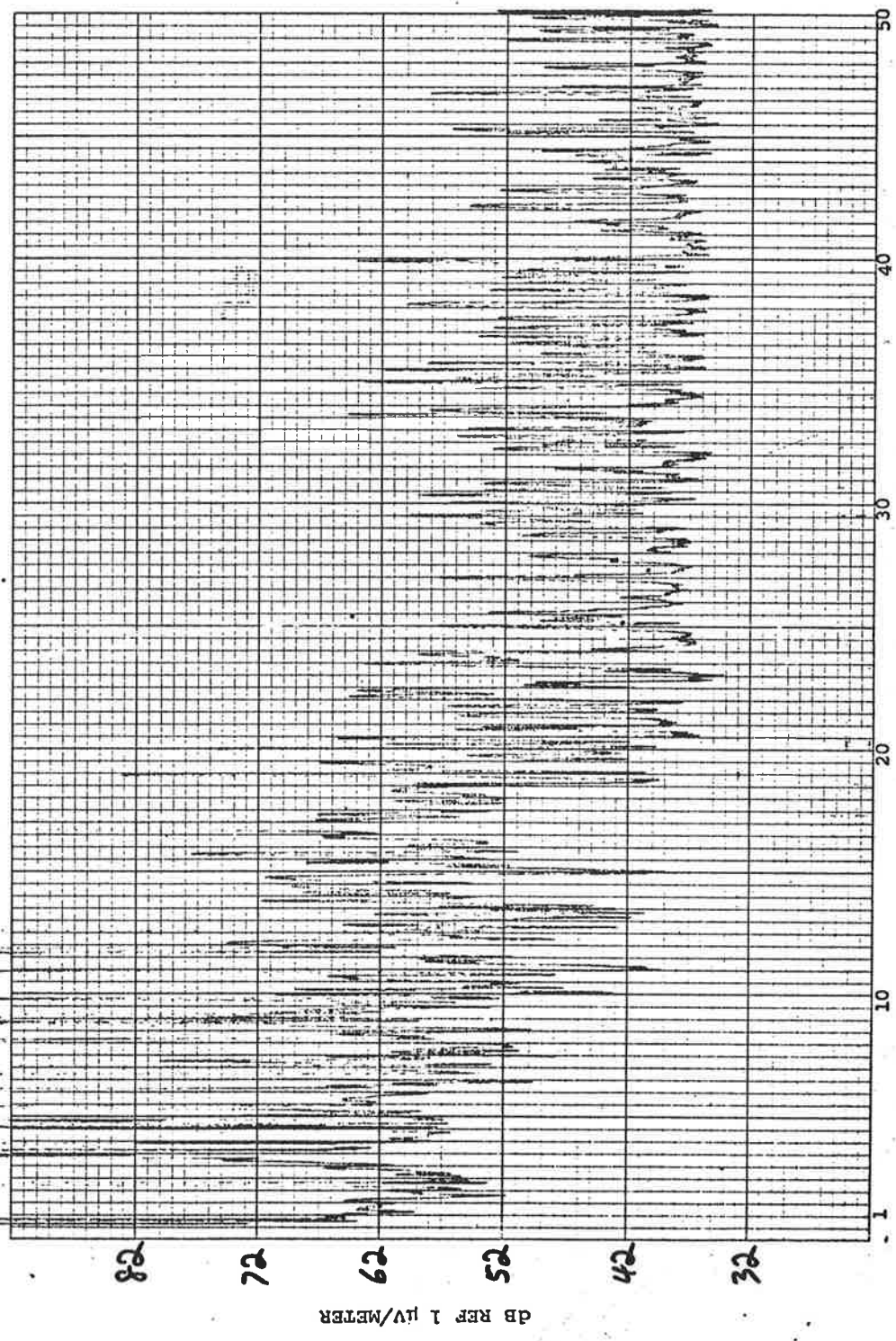
FREQUENCY - KHZ



1100  
EJ

TEST TYPE ESR E/W BANDWIDTH 50 Hz  
TEST EQUIP. EMC-10 DATE 7-26-72

TEST NO. 204  
TEST SPECIMEN 867

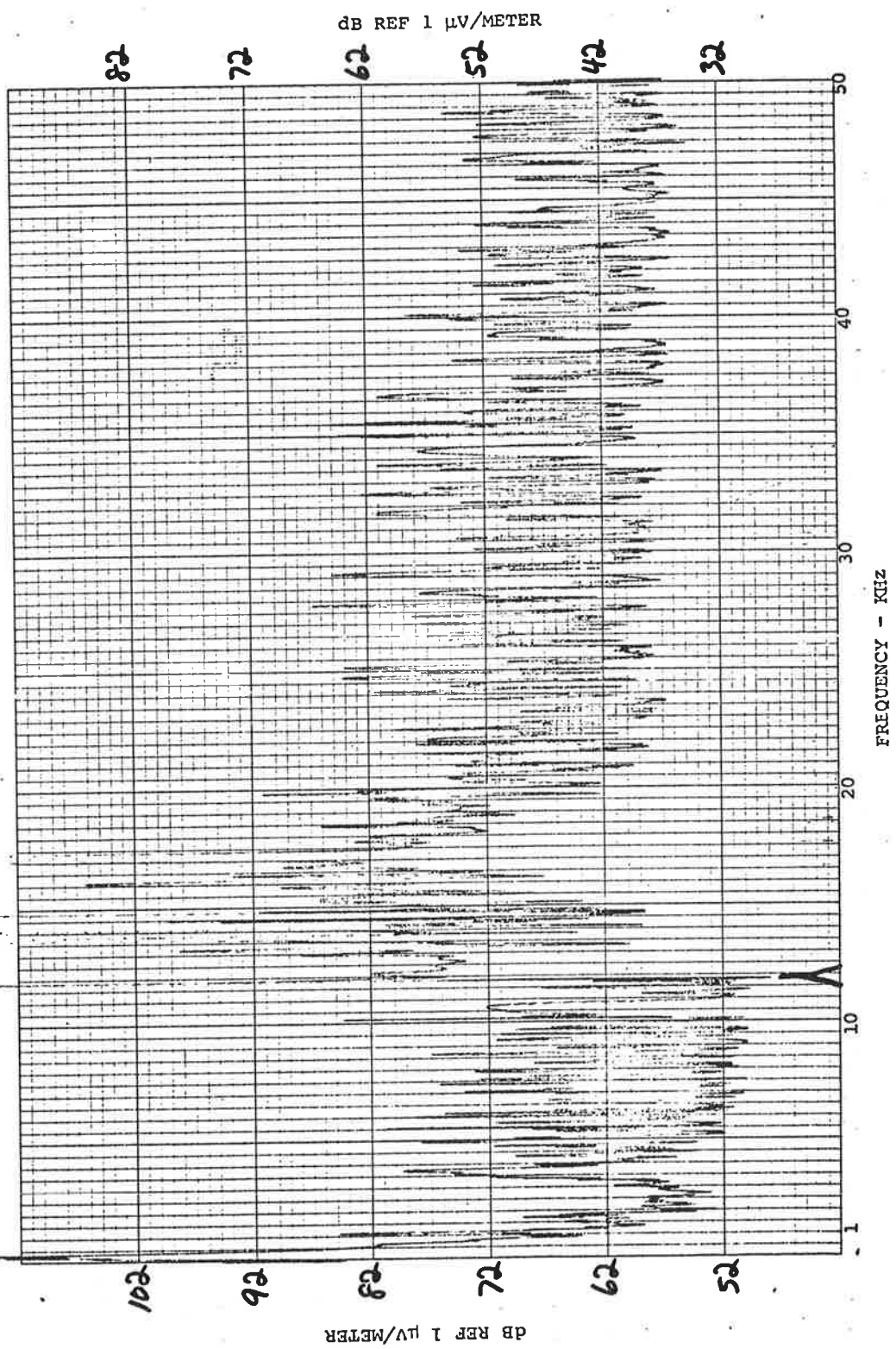


1106  
EJ

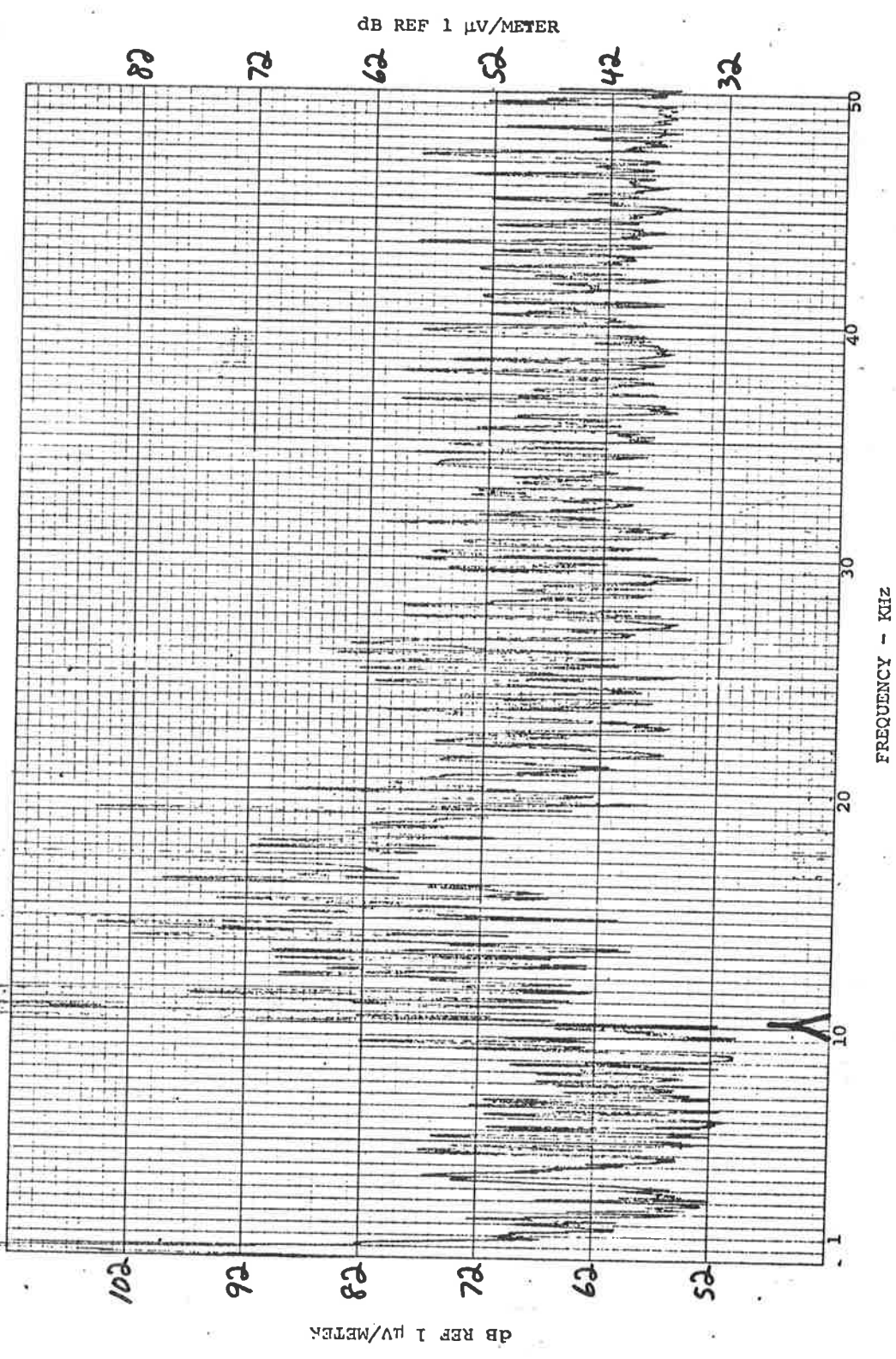
BANDWIDTH 50Hz  
DATE 7-26-72

TEST TYPE ESR N/S  
TEST EQUIP. EMC-10

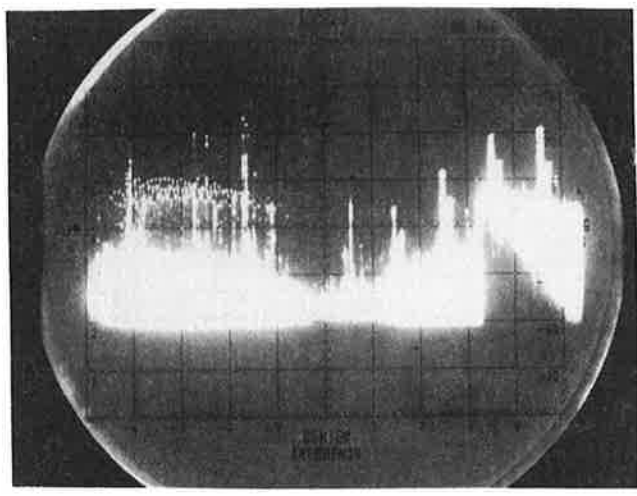
TEST NO. 205  
TEST SPECIMEN 267



TEST NO. 206 TEST TYPE ESR N-S BANDWIDTH 50 Hz 1112  
 TEST SPECIMEN SITE 1 TEST EQUIP. EMC-10 DATE 7-26-72 VRC



LOCATION: SITE 7 TYPE TEST ESR DATE 7-26-72

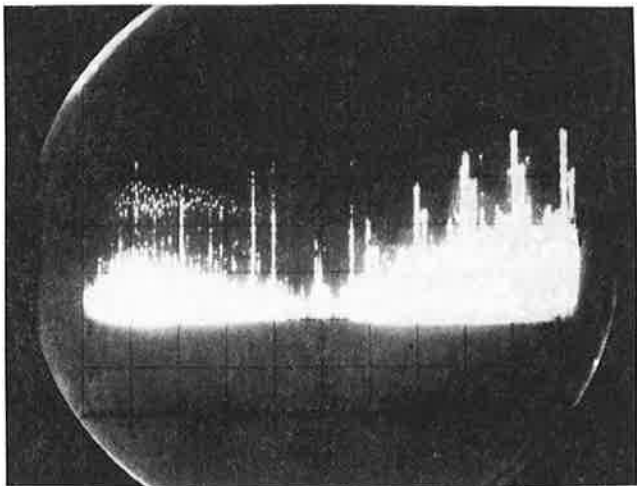


153  
133  
113  
93  
73  
dB REF 1  $\mu$ V/METER/MHZ

TEST 207  
TIME 1127

50 FREQ. 75 KHz 100

FREQ. SCAN: 5 KHz/Div.  
Bandwidth: 10 KHz

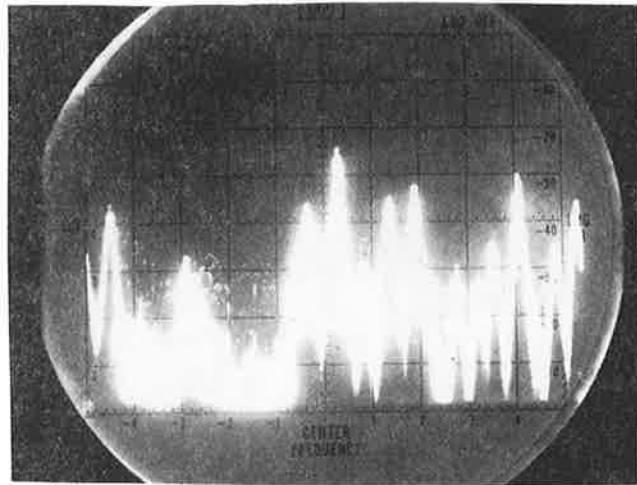


153  
133  
113  
93  
73  
dB REF 1  $\mu$ V/METER/MHZ

TEST 207  
TIME 1129



LOCATION: SITE 7 TYPE TEST ESR DATE 7-26-72



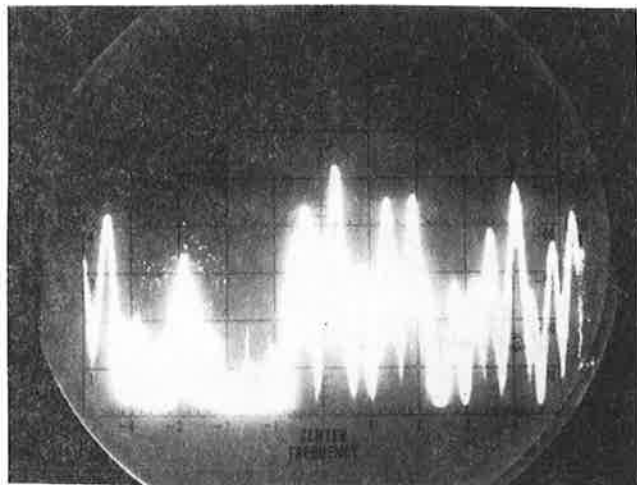
153  
133  
113  
93  
73  
dB REF 1  $\mu$ V/METER/MHZ

TEST 208  
TIME 1135

0.1 FREQ. 0.6 MHz 1.1

FREQ. SCAN: 0.1 MHz/Div.

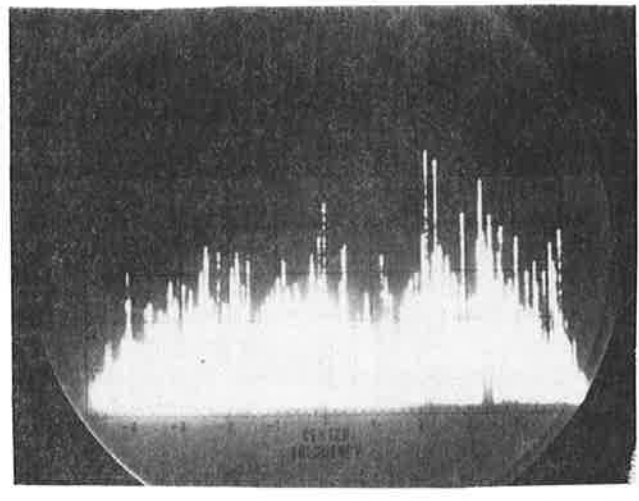
Bandwidth: 10 KHz



153  
133  
113  
93  
73  
dB REF 1  $\mu$ V/METER/MHZ

TEST 208  
TIME 1140

LOCATION: SITE 7 TYPE TEST ESR DATE 7-26-72

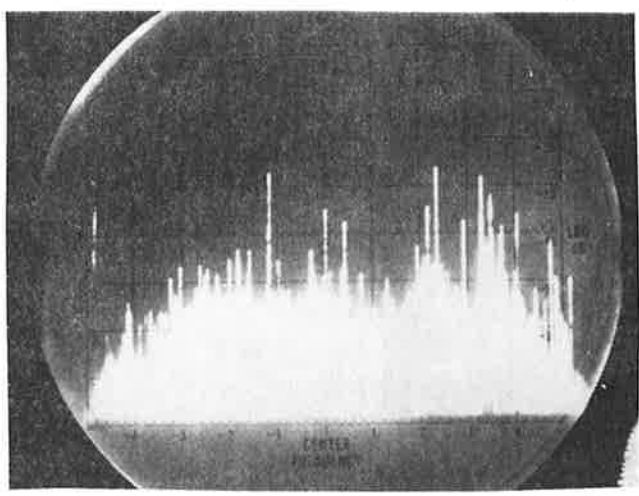


143  
123  
103  
83  
63

TEST 209  
TIME 1143

1      11      21  
FREQ.      MHz

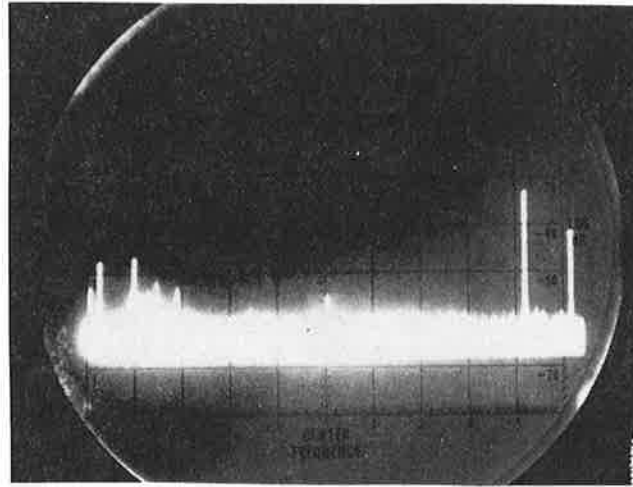
FREQ. SCAN: 2MHz/Div.  
Bandwidth: 10 KHz



143  
123  
103  
83  
63

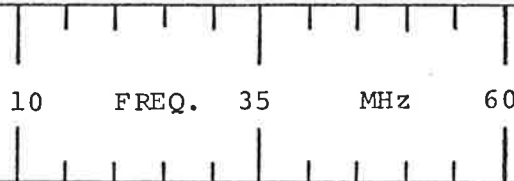
TEST 209  
TIME 1144

LOCATION: SITE 7 TYPE TEST ESR E/W DATE 7-26-72

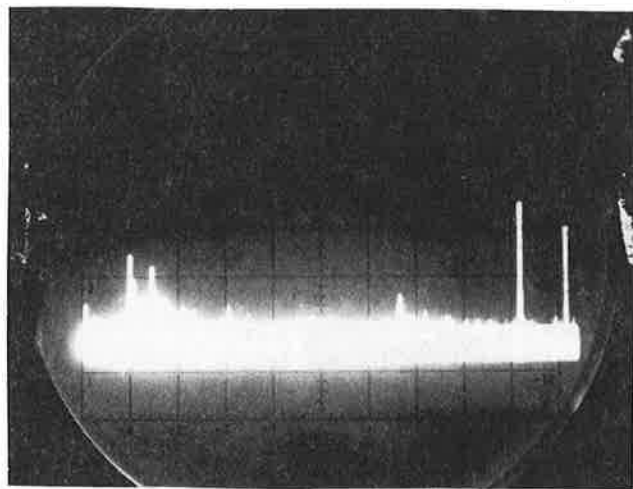


115  
95  
75  
55  
35

TEST 210  
TIME 1149



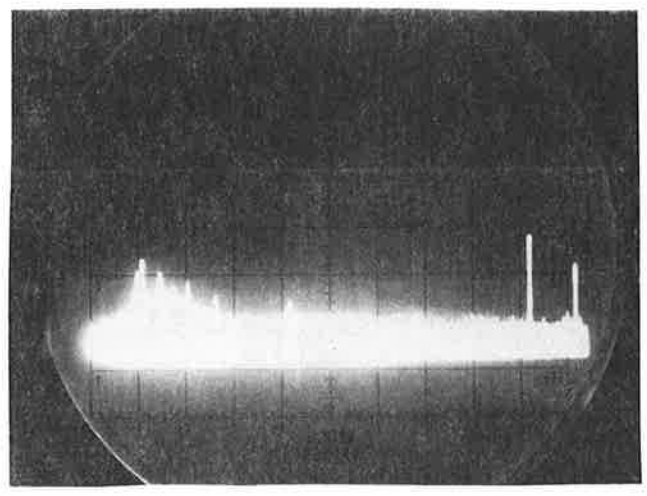
FREQ. SCAN: 5MHz/Div.  
Bandwidth: 10 KHz



115  
95  
75  
55  
35

TEST 210  
TIME 1150

LOCATION: SITE 7 TYPE TEST ESR N/S DATE 7-26-72

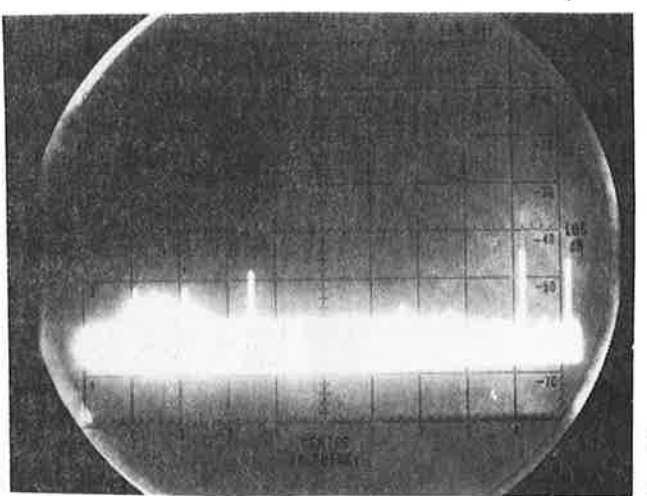


115  
95  
75  
55  
35  
dB REF 1  $\mu$ V/METER/MHZ

TEST 211  
TIME 1152

10 FREQ. 35 MHz 60

FREQ. SCAN: 5MHz/Div.  
Bandwidth: 10 KHz



115  
95  
75  
55  
35  
dB REF 1  $\mu$ V/METER/MHZ

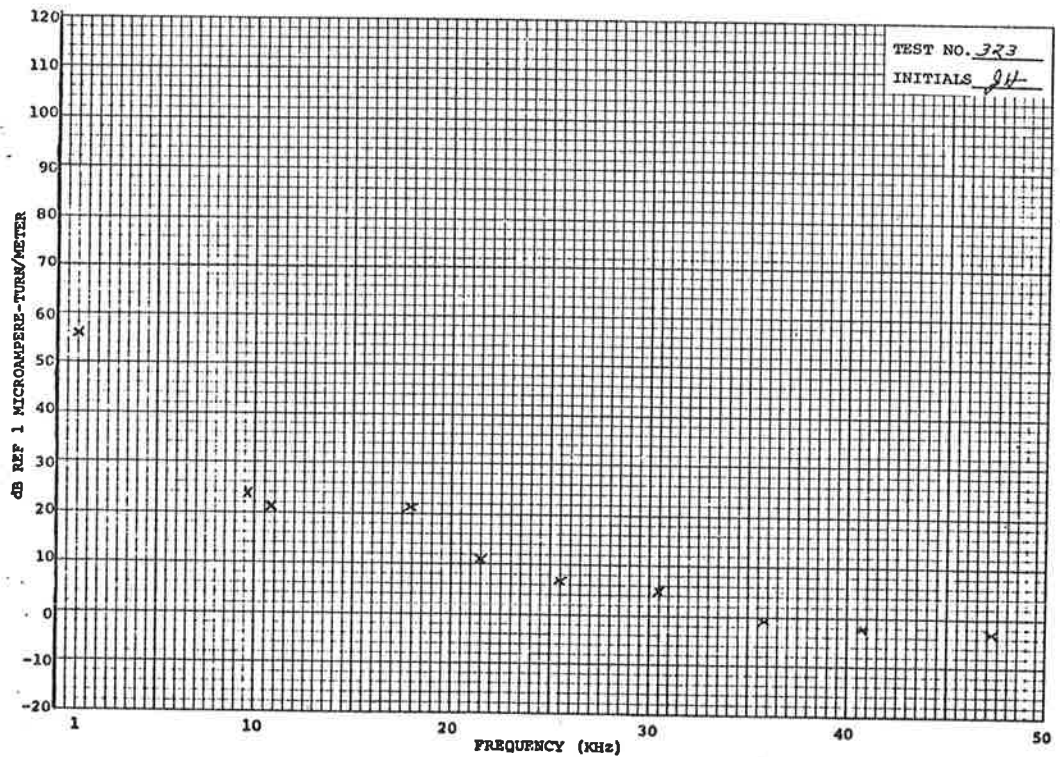
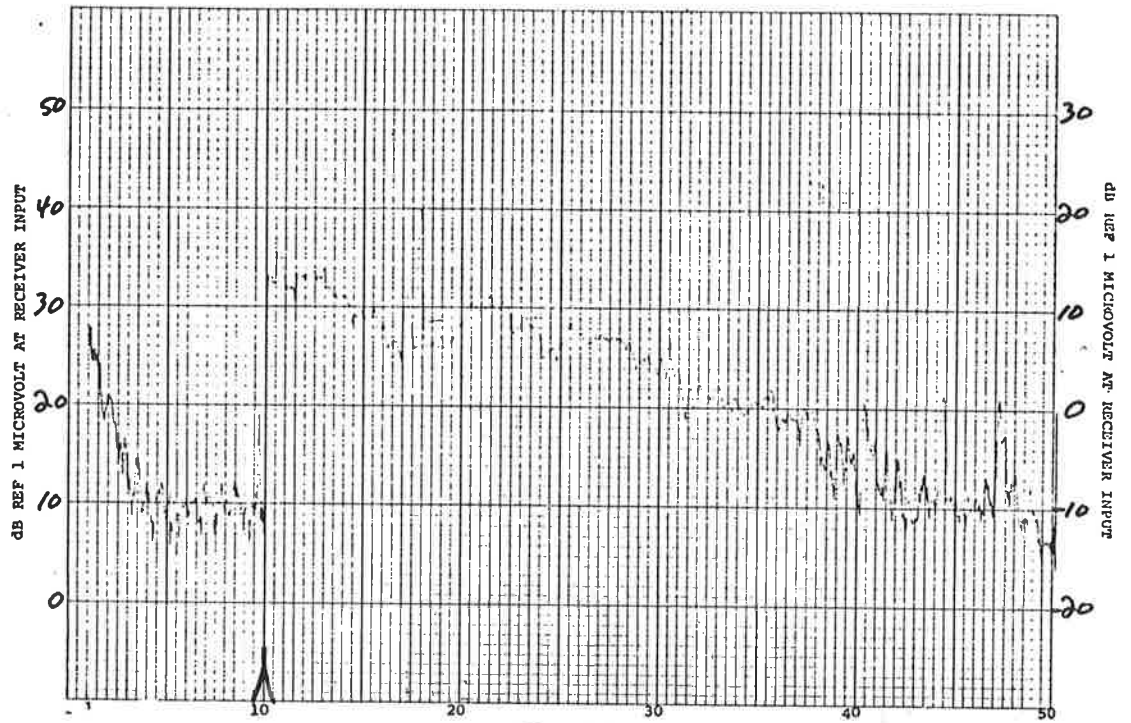
TEST 211  
TIME 1153

TEST NO. 323  
TEST SPECIMEN J-6 B

TEST TYPE MSR E/W  
TEST EQUIP. FM-10

BANDWIDTH 50Hz  
DATE 7-22-72

1518  
SSJ



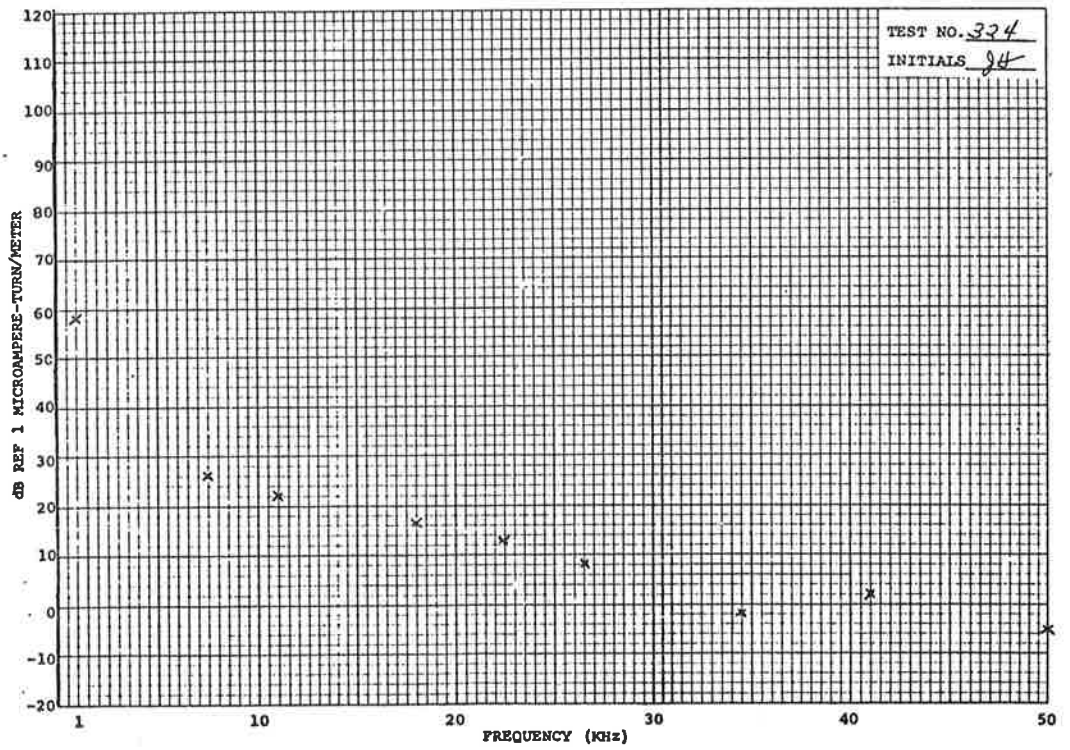
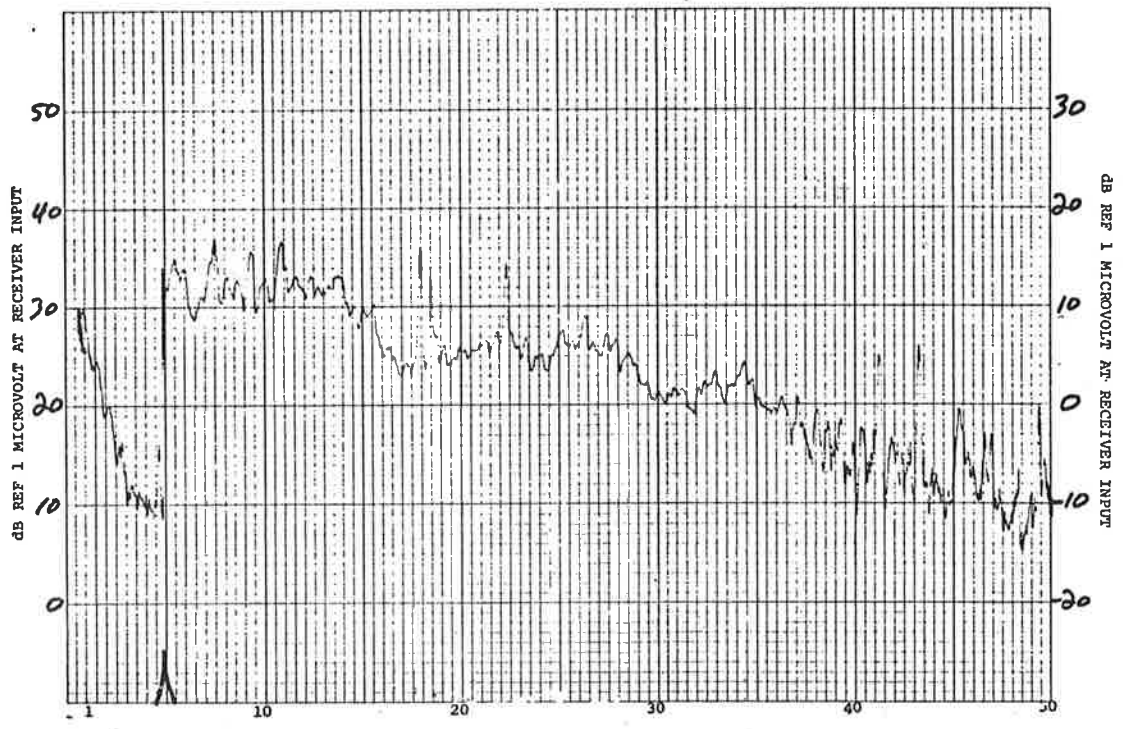
TEST NO. 323  
INITIALS SSJ

TEST NO. 324  
TEST SPECIMEN 26A

TEST TYPE MSR F/W  
TEST EQUIP. FMC-10

BANDWIDTH 50Hz  
DATE 7-28-72

152-1  
859



TEST NO. 324  
INITIALS JH

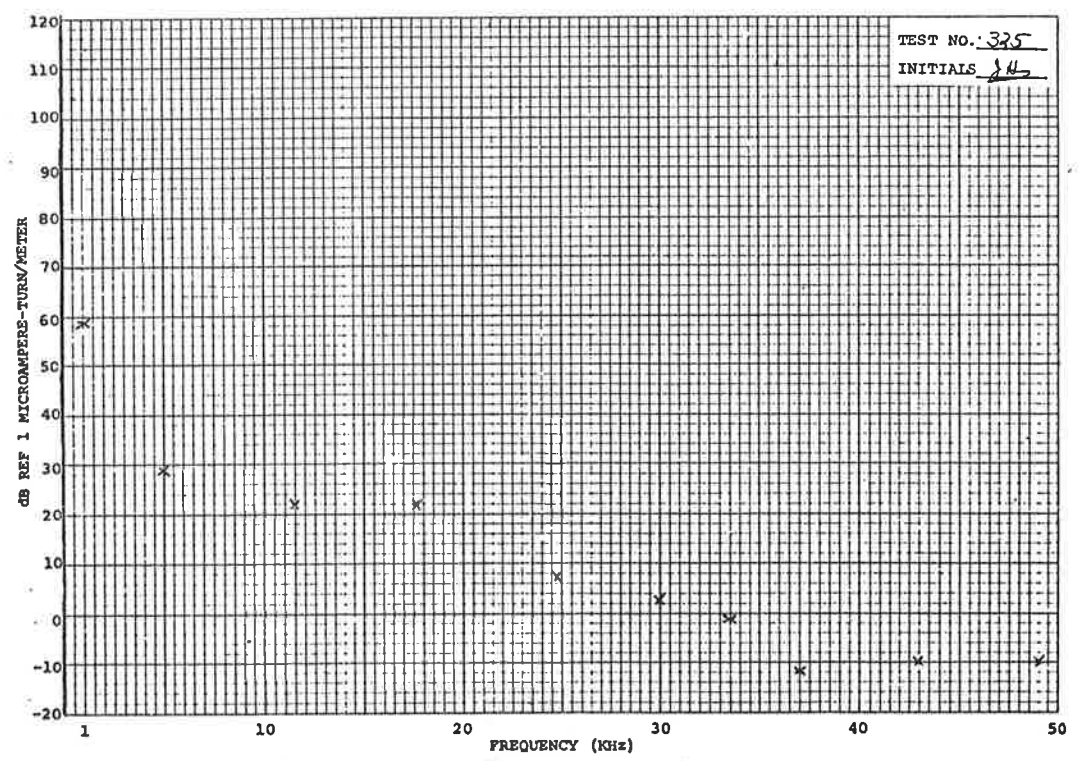
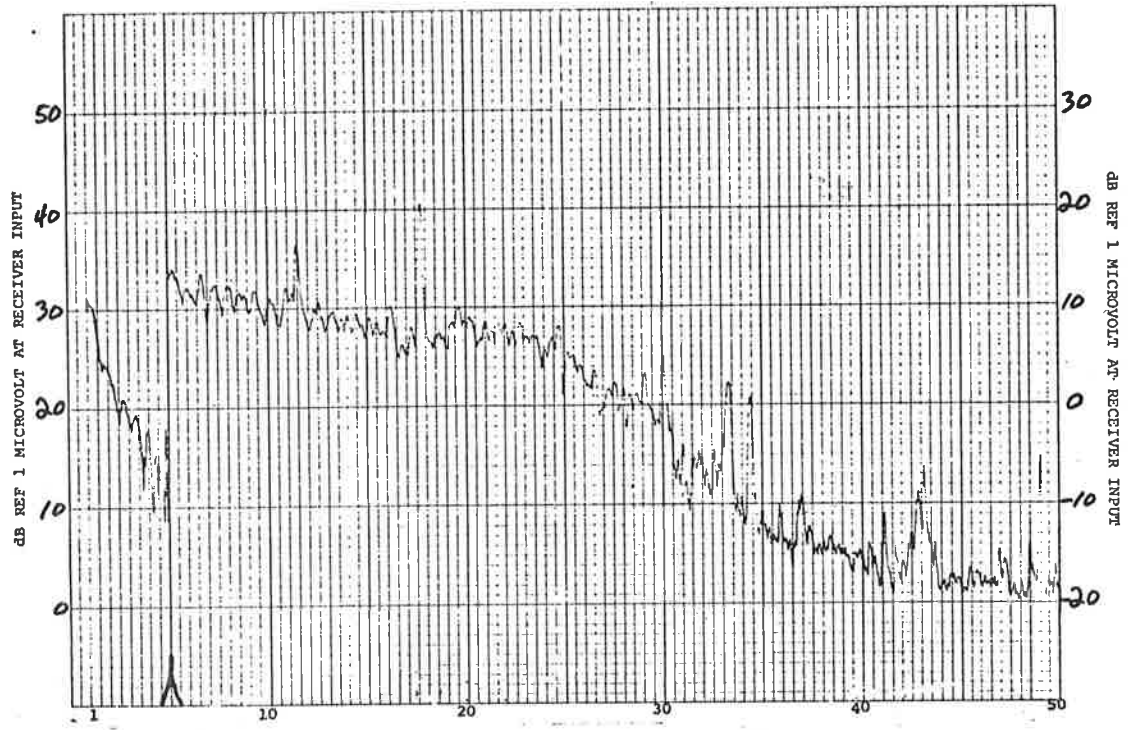


TEST NO. 325  
TEST SPECIMEN X68

TEST TYPE MSR N/S  
TEST EQUIP. ENC-10

BANDWIDTH 50Hz  
DATE 7-28-72

1584  
EQ

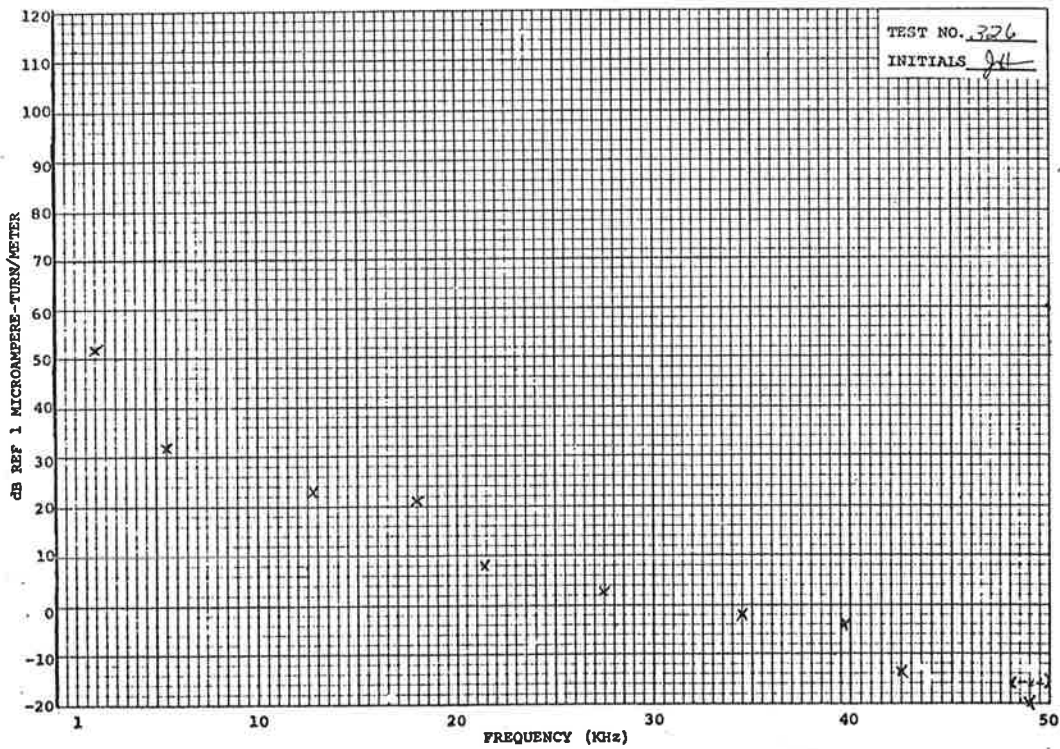
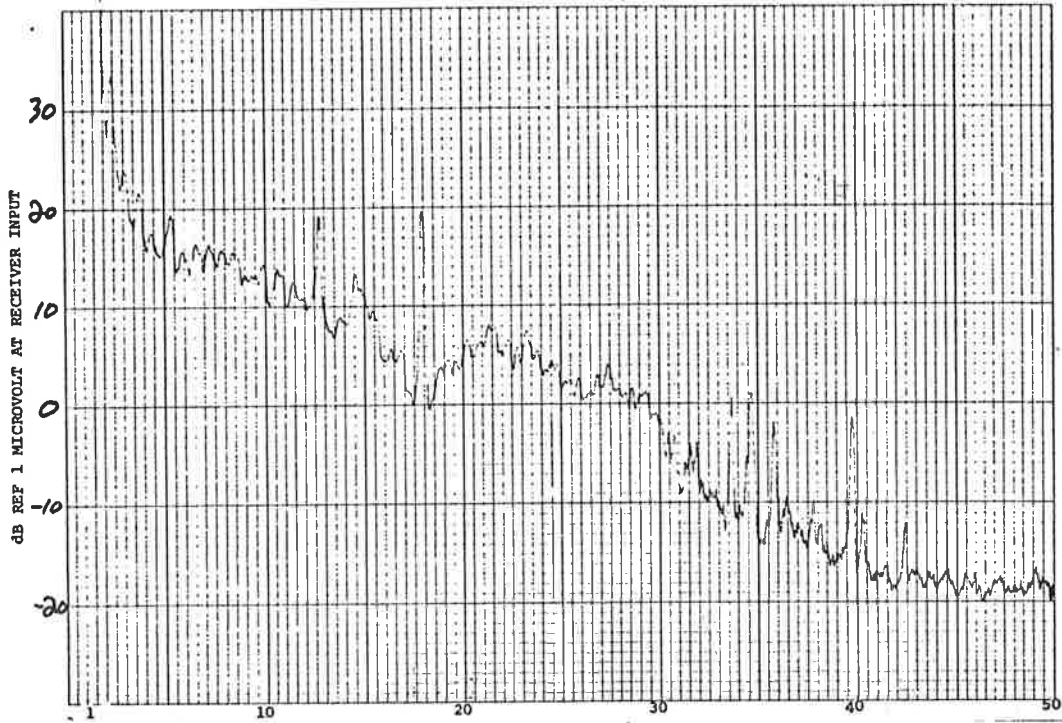


TEST NO. 326  
TEST SPECIMEN 326A

TEST TYPE MSR N/S  
TEST EQUIP. PMC-10

BANDWIDTH 50Hz  
DATE 7-28-72

1586  
889



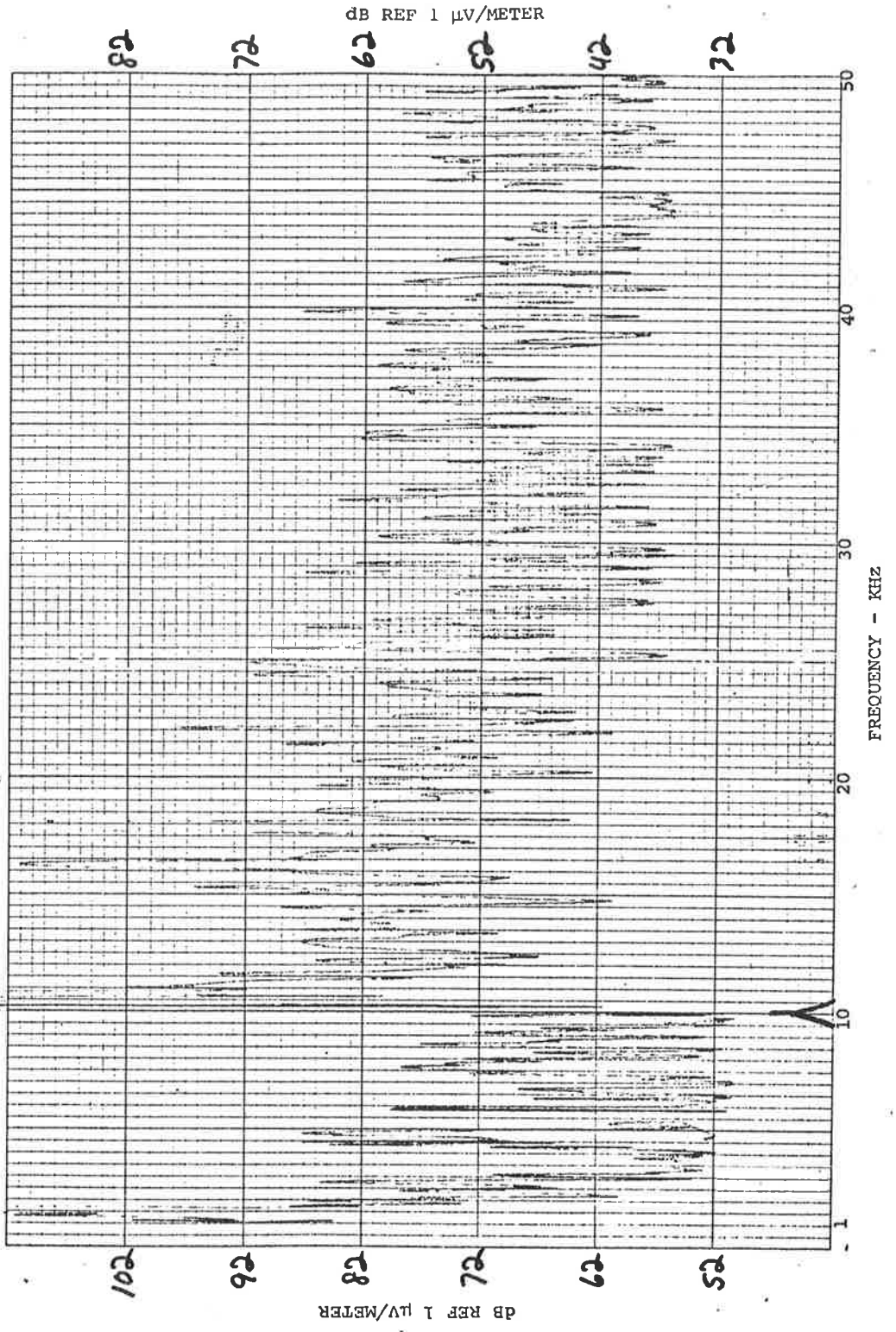


242  
F33  
2421

BANDWIDTH 50Hz  
DATE 7-25-72

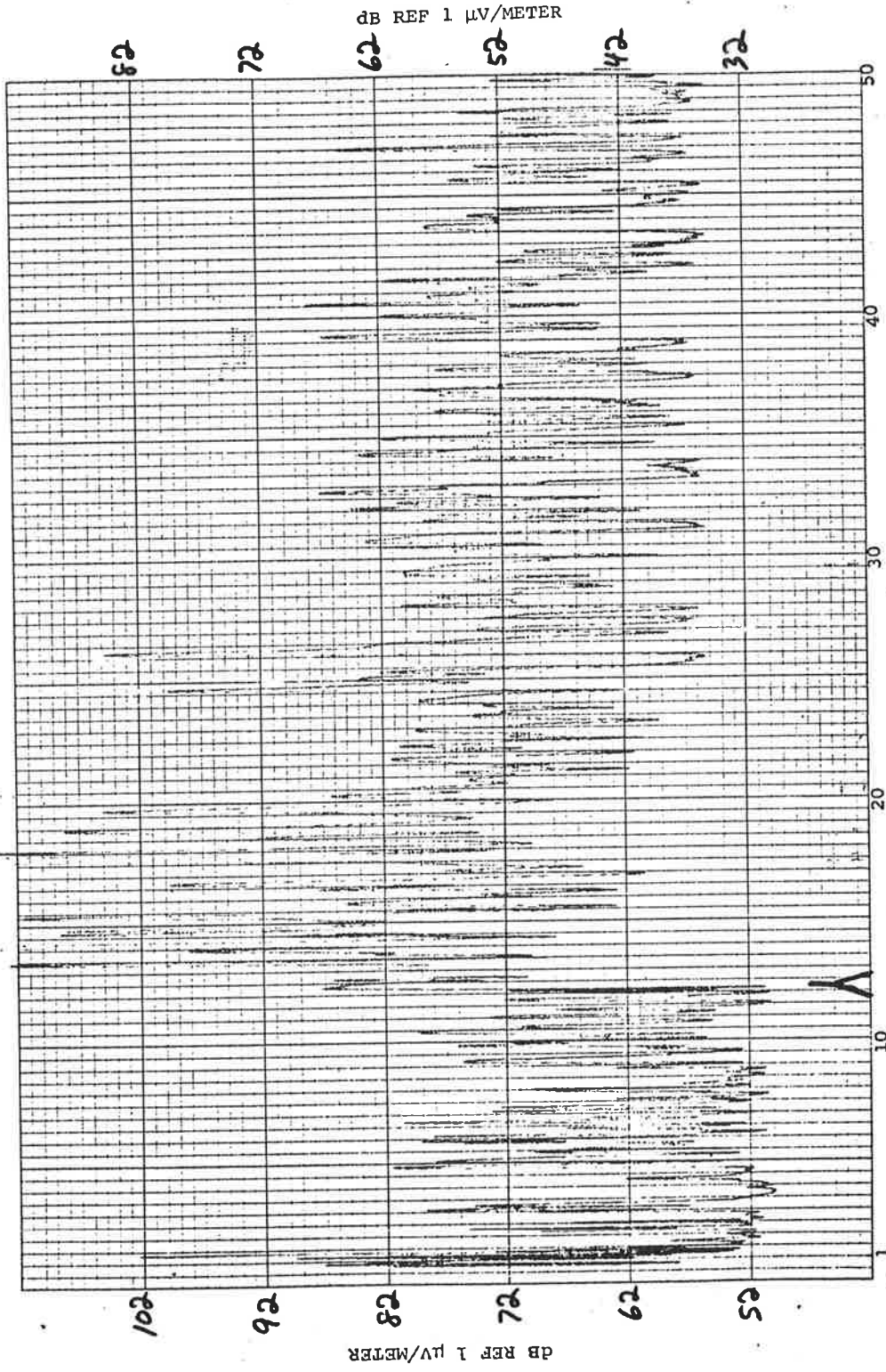
TEST TYPE ESR E/w  
TEST EQUIP. EMC-10

TEST NO. 219  
TEST SPECIMEN ~~219~~ B



1246  
JRC

TEST NO. 220  
TEST SPECIMEN STE 8  
TEST TYPE ESR E-W  
TEST EQUIP. EMC-10  
BANDWIDTH 50Hz  
DATE 7/25/72

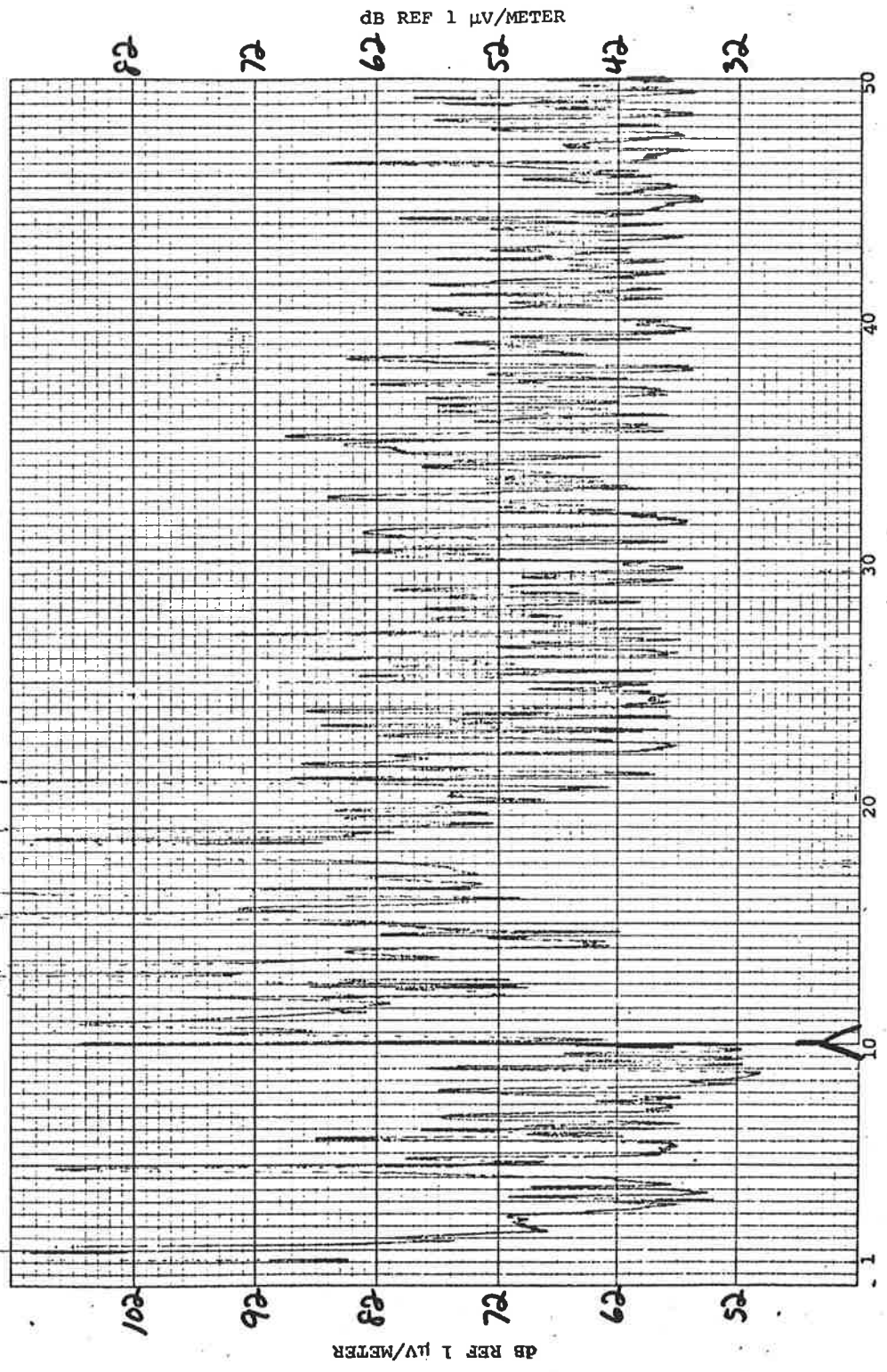


1231  
EJ

BANDWIDTH 50Hz  
DATE 7-26-72

TEST TYPE ESR N/S  
TEST EQUIP. EMC-10

TEST NO. 217  
TEST SPECIMEN Site 8

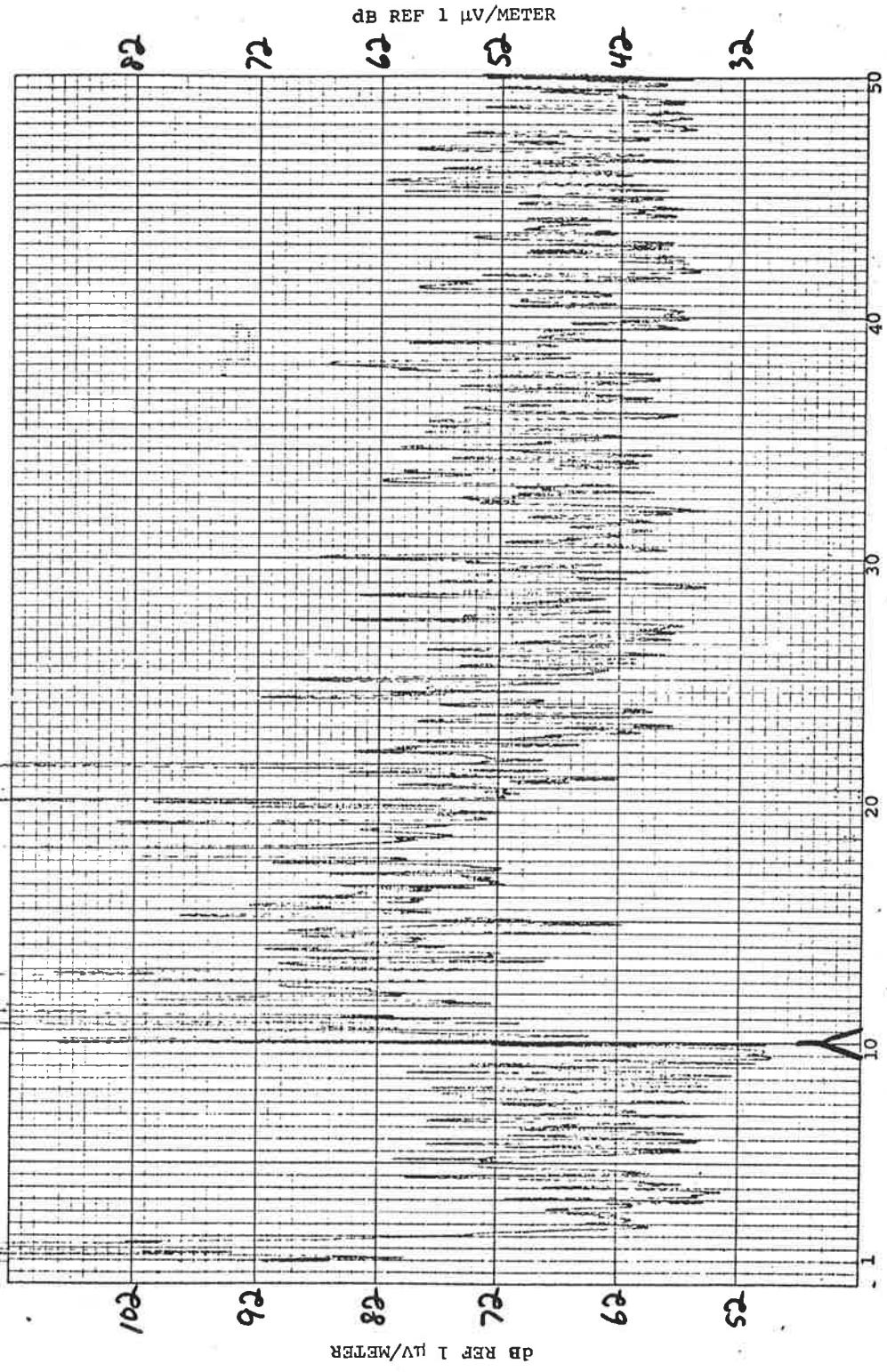


1236  
R33

BANDWIDTH 50Hz  
DATE 7-26-72

TEST TYPE ESR N/S  
TEST EQUIP. ENC-10

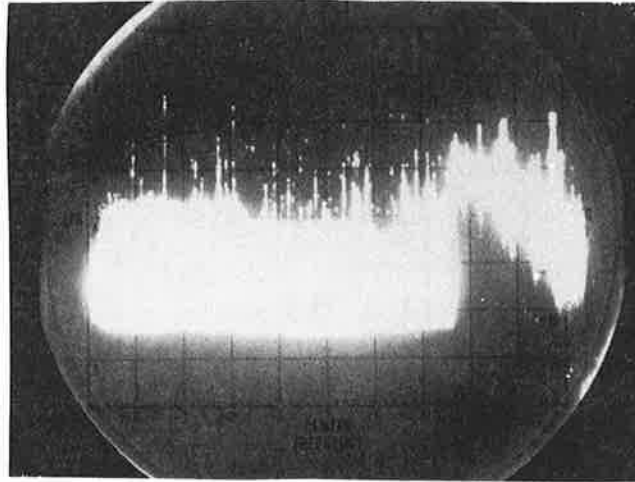
TEST NO. 218  
TEST SPECIMEN 2 & 8



dB REF 1 μV/METER

FREQUENCY - KHZ

LOCATION: SITE 8 TYPE TEST ESR DATE 7-26-72

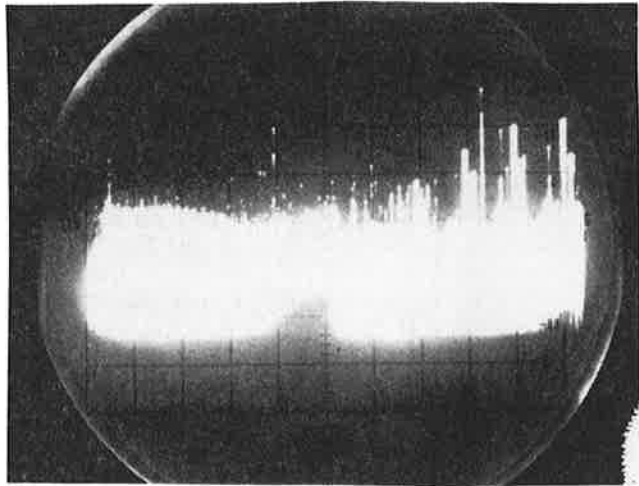


153  
133  
113  
93  
73

TEST 216  
TIME 1226

50 FREQ. 75 KHz 100

FREQ. SCAN: 5 KHz/Div.  
Bandwidth: 10 KHz

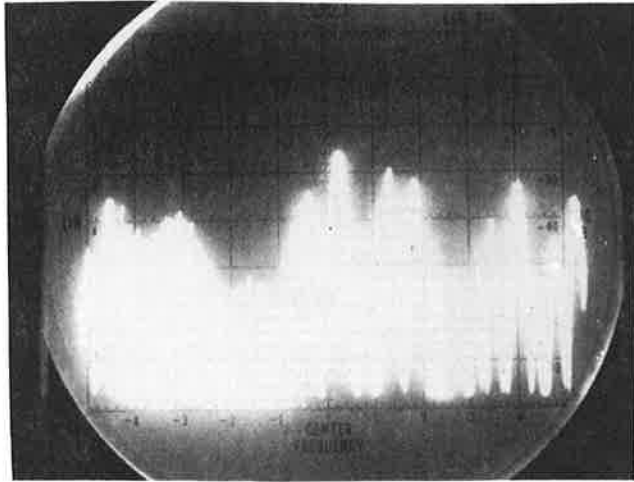


153  
133  
113  
93  
73

TEST 216  
TIME 1228



LOCATION: SITE 8 TYPE TEST ESR DATE 7-26-72

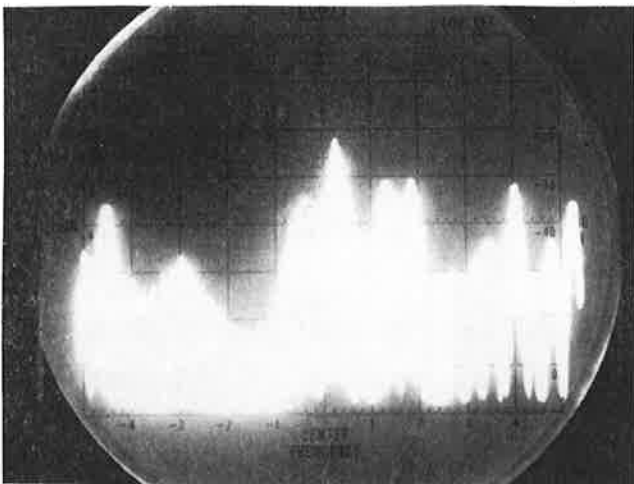


153  
133  
113  
93  
73  
dB REF 1  $\mu$ V/METER/MHZ

TEST 215  
TIME 1222

0.1    0.6    1.1  
FREQ.    MHz

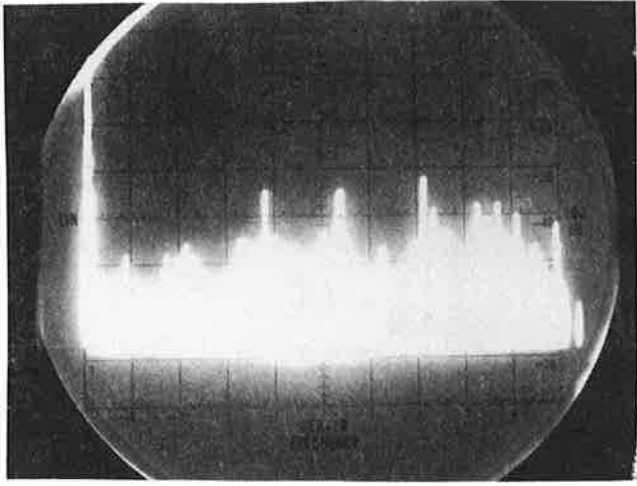
FREQ. SCAN: 0.1 MHz/Div.  
Bandwidth: 10 KHz



153  
133  
113  
93  
73  
dB REF 1  $\mu$ V/METER/MHZ

TEST 215  
TIME 1224

LOCATION: SITE 8 TYPE TEST ESR DATE 7-26-72

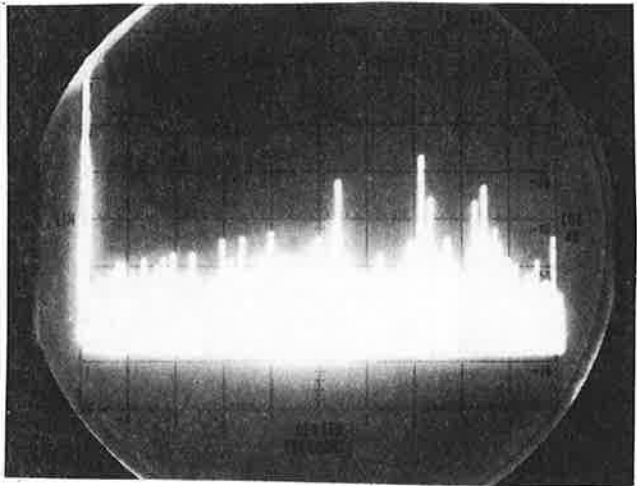


143  
-123  
-103  
dB REF 1  $\mu$ V/METER/MHZ  
83  
63

TEST 214  
TIME 1216

FREQ. 11 MHz 21

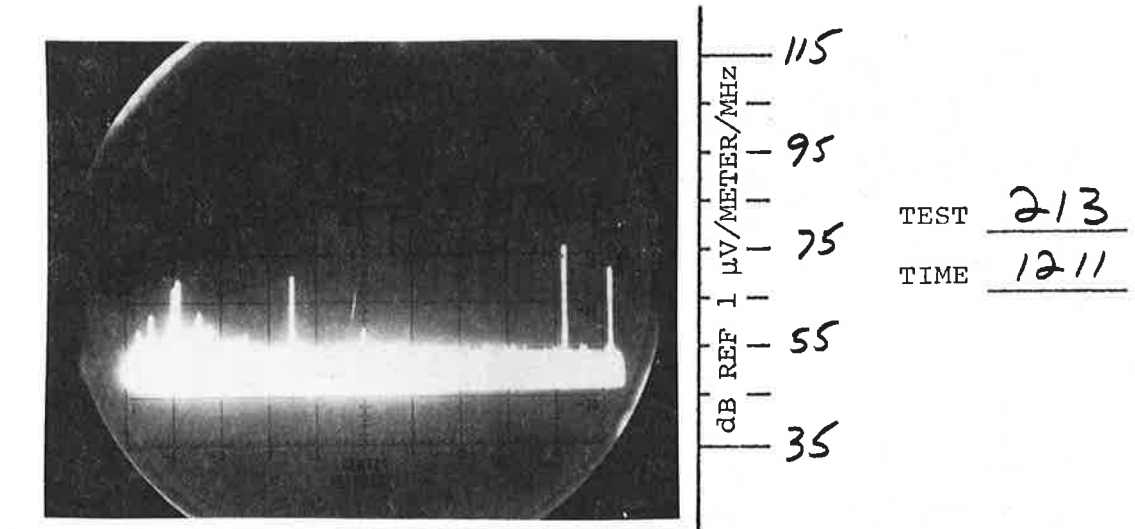
FREQ. SCAN: 2MHz/Div.  
Bandwidth: 10 KHz



143  
-123  
-103  
dB REF 1  $\mu$ V/METER/MHZ  
83  
63

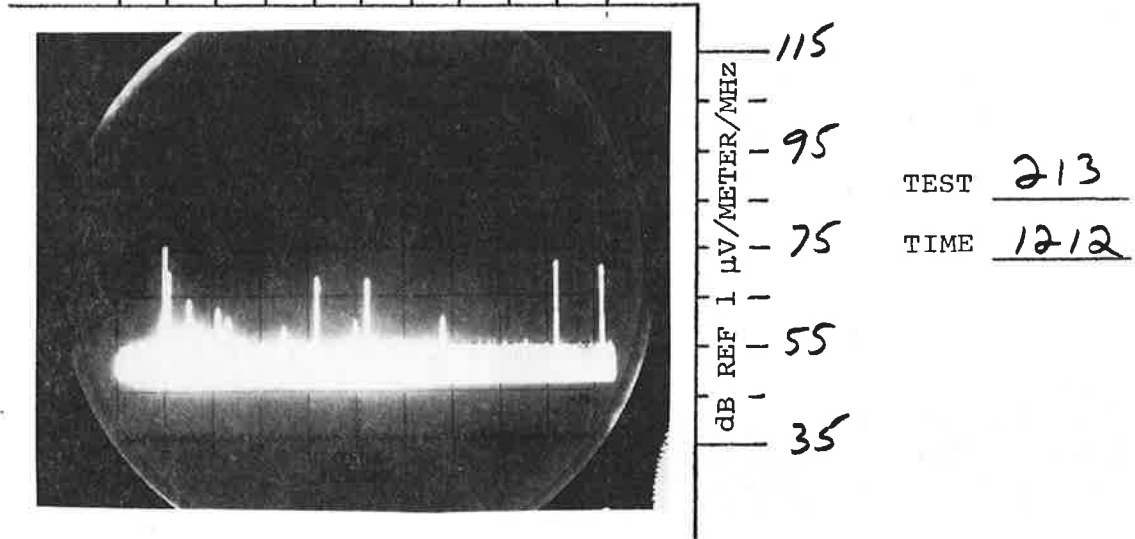
TEST 214  
TIME 1217

LOCATION: SITE 8 TYPE TEST ESR E/W DATE 7-26-72



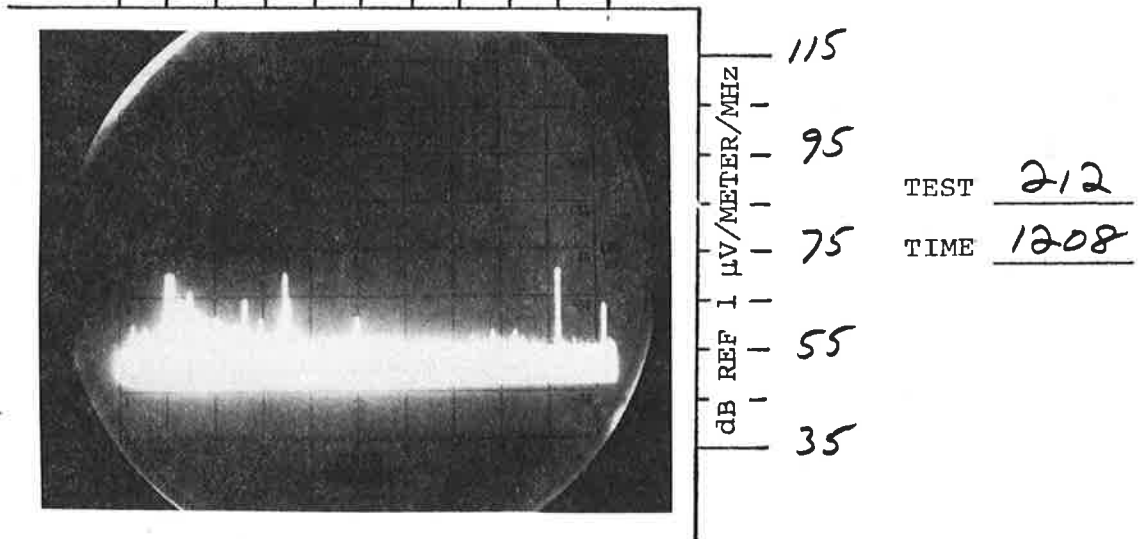
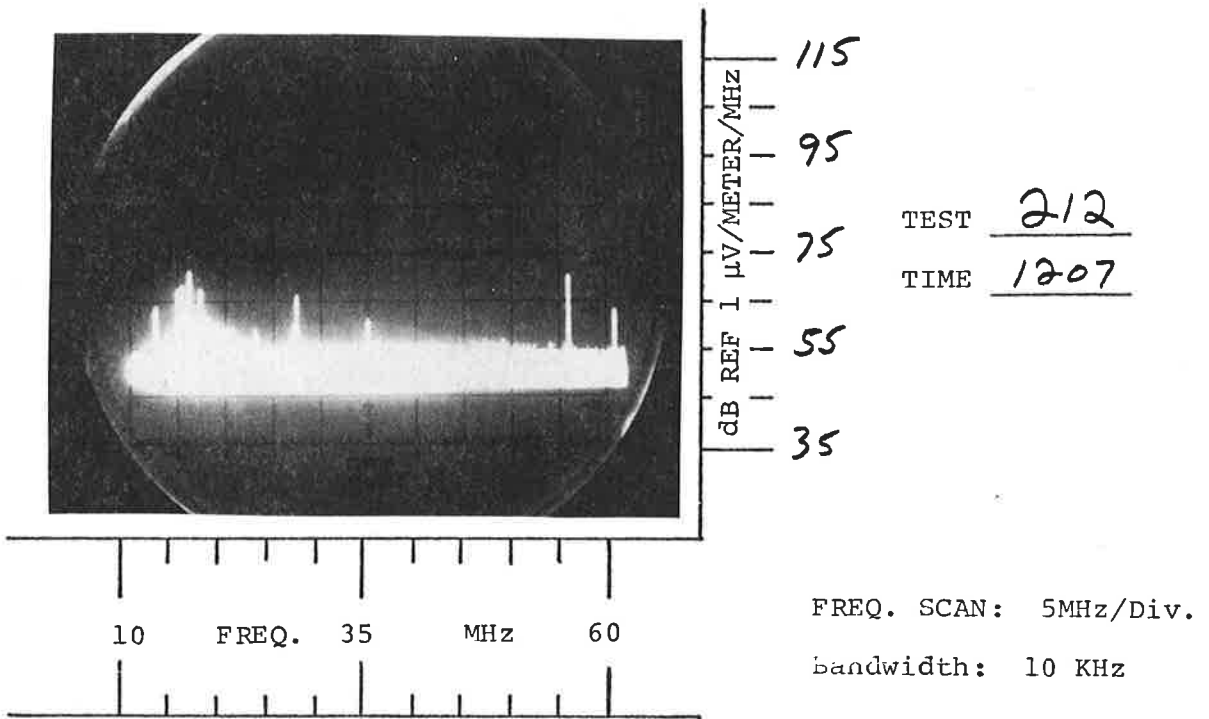
10 FREQ. 35 MHz 60

FREQ. SCAN: 5MHz/Div.  
Bandwidth: 10 KHz





LOCATION: SITE 8 TYPE TEST ESR N/S DATE 7-26-72

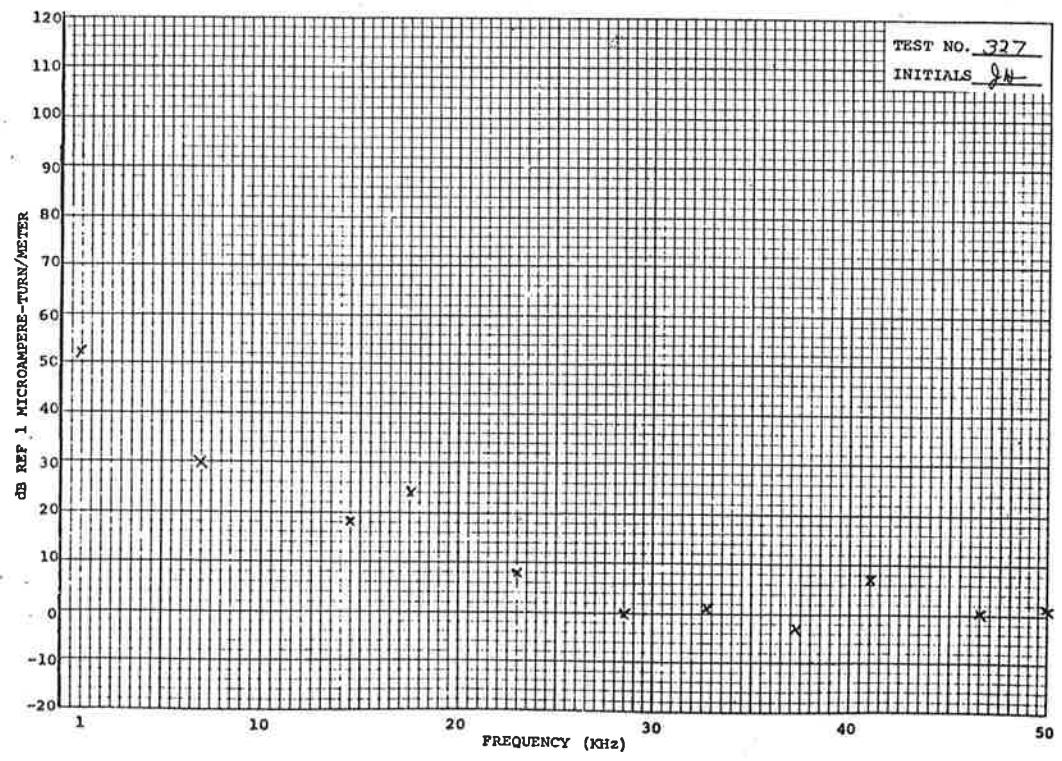
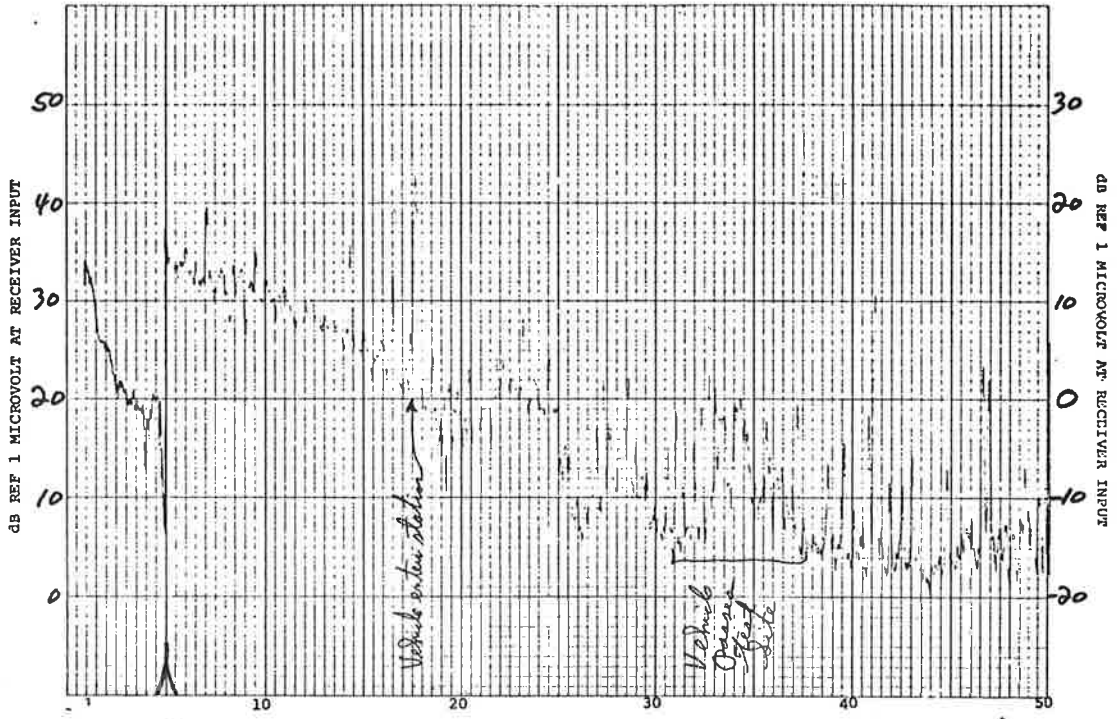


TEST NO. 327  
 TEST SPECIMEN 8166

TEST TYPE MSR E/W  
 TEST EQUIP. KAC 10

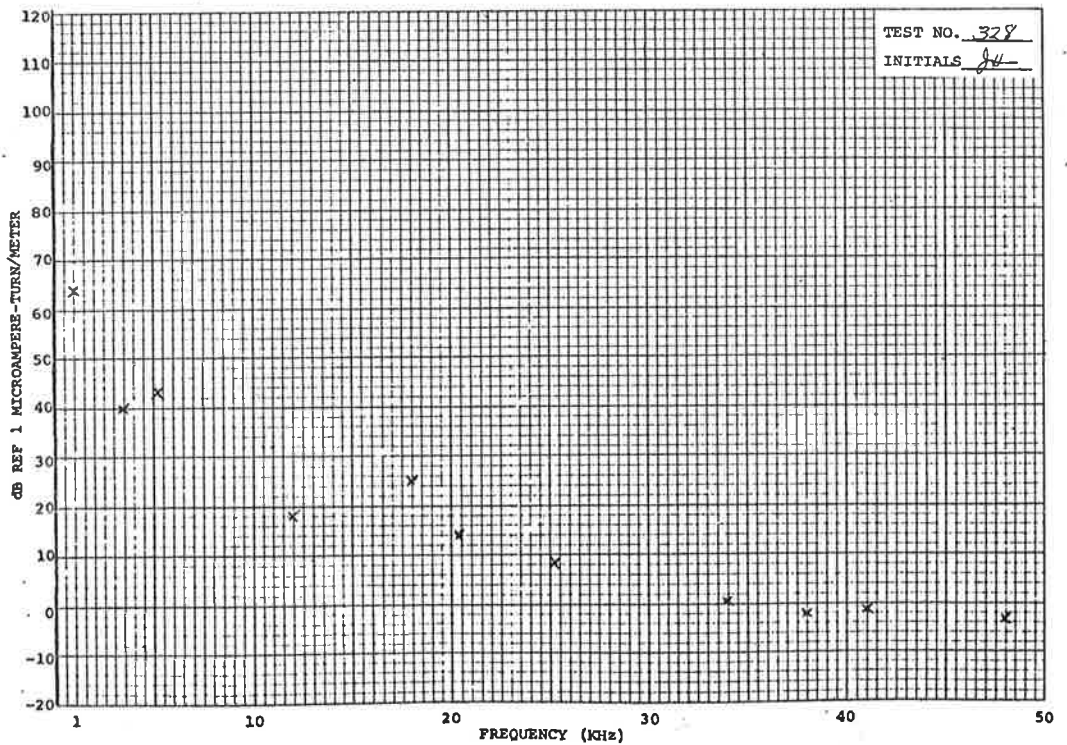
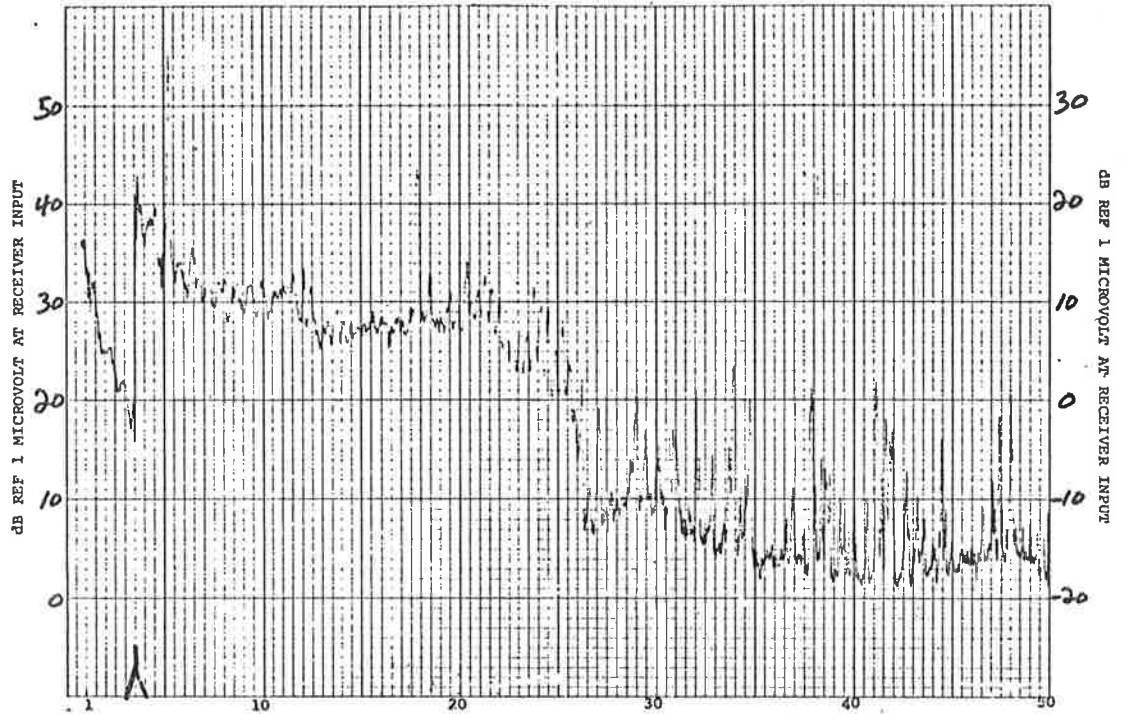
BANDWIDTH 50Hz  
 DATE 1-24-72

1531  
 58



TEST NO. 328 TEST TYPE MSR E/W BANDWIDTH 50 Hz  
 TEST SPECIMEN Site 6 TEST EQUIP. ENC-10 DATE 7-28-72

1535  
 SGT

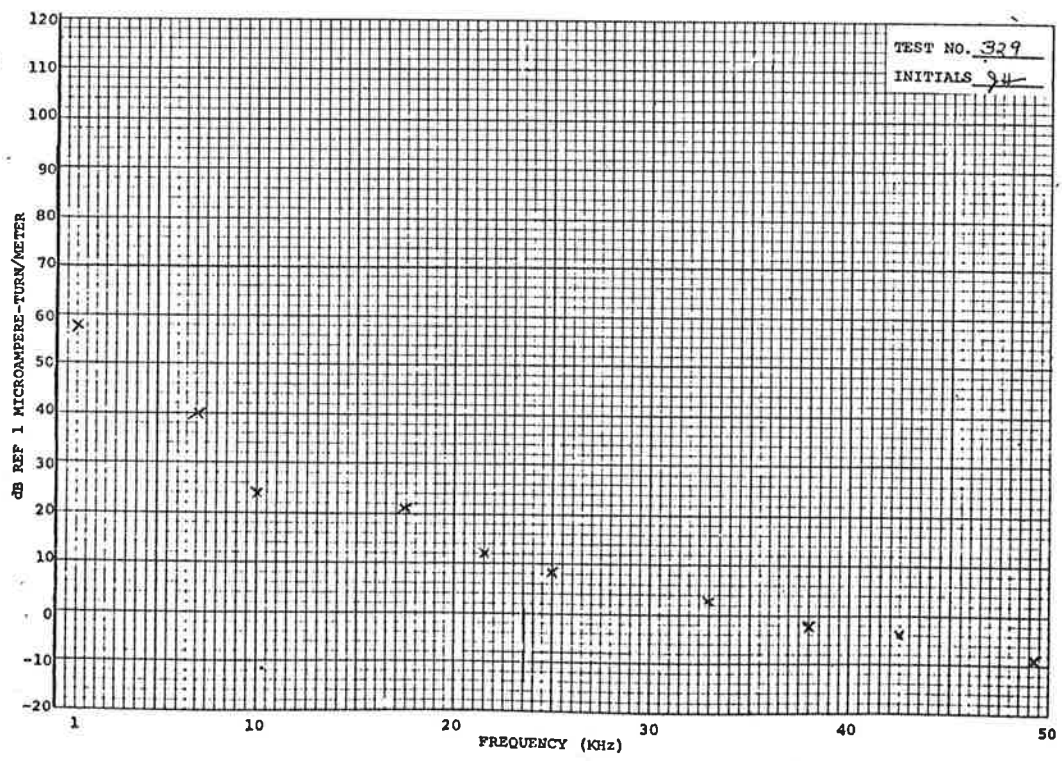
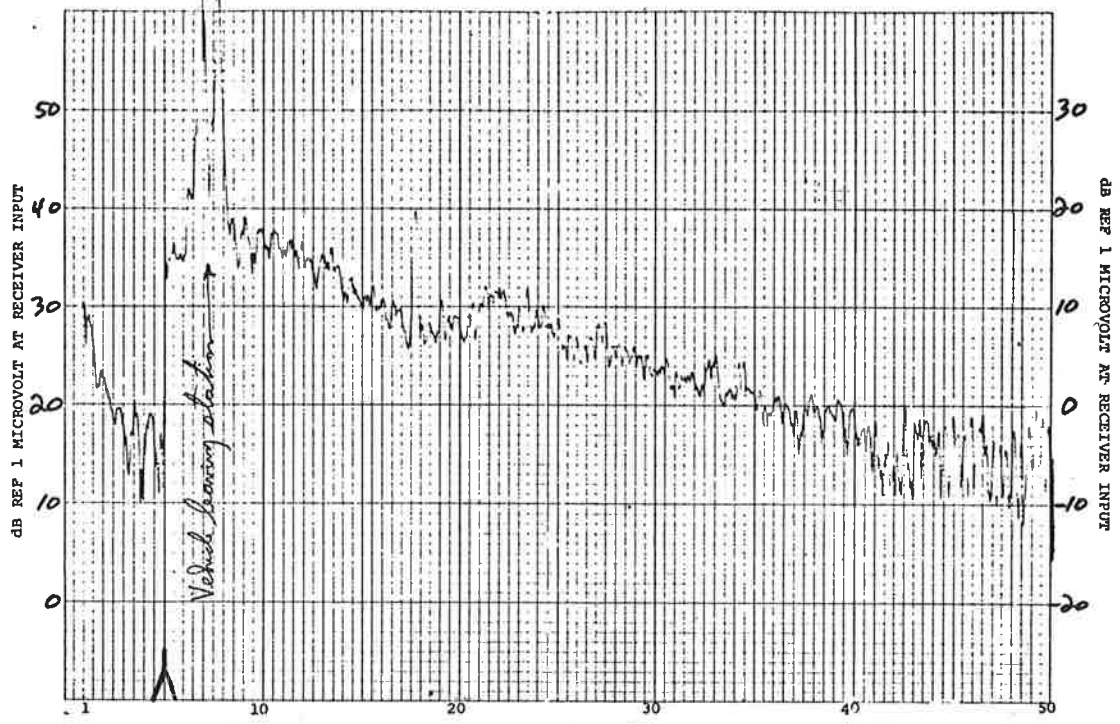


TEST NO. 329  
TEST SPECIMEN 866

TEST TYPE MSR N/W  
TEST EQUIP. ENC-10

BANDWIDTH 50Hz  
DATE 7-28-72

1540  
ESJ



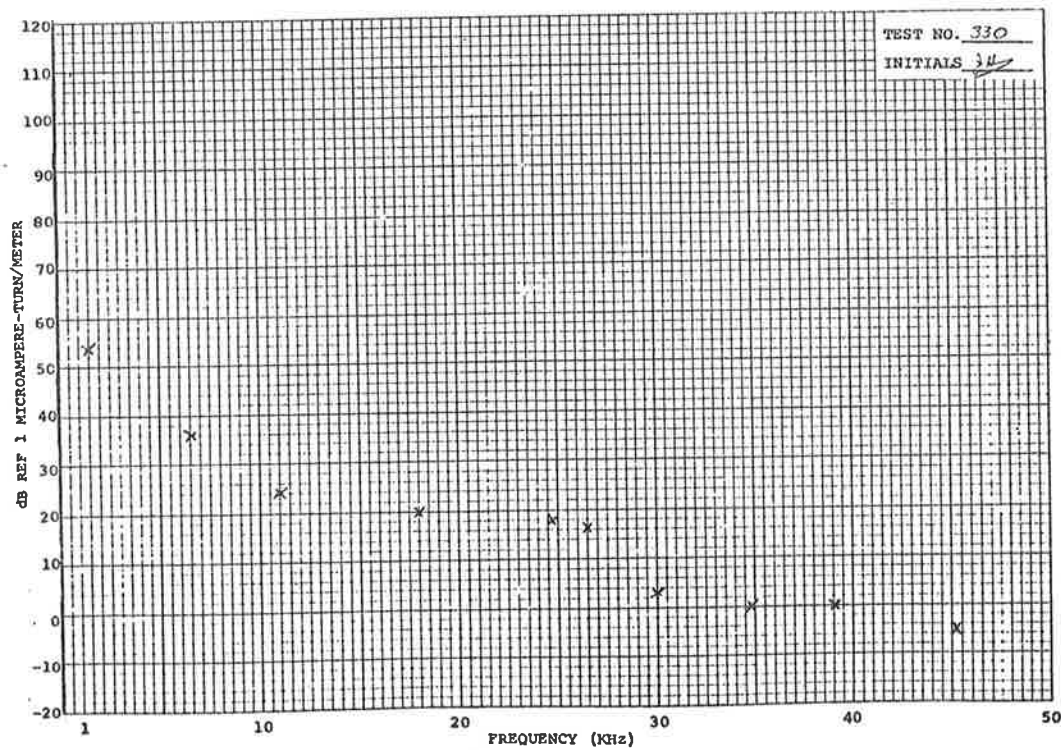
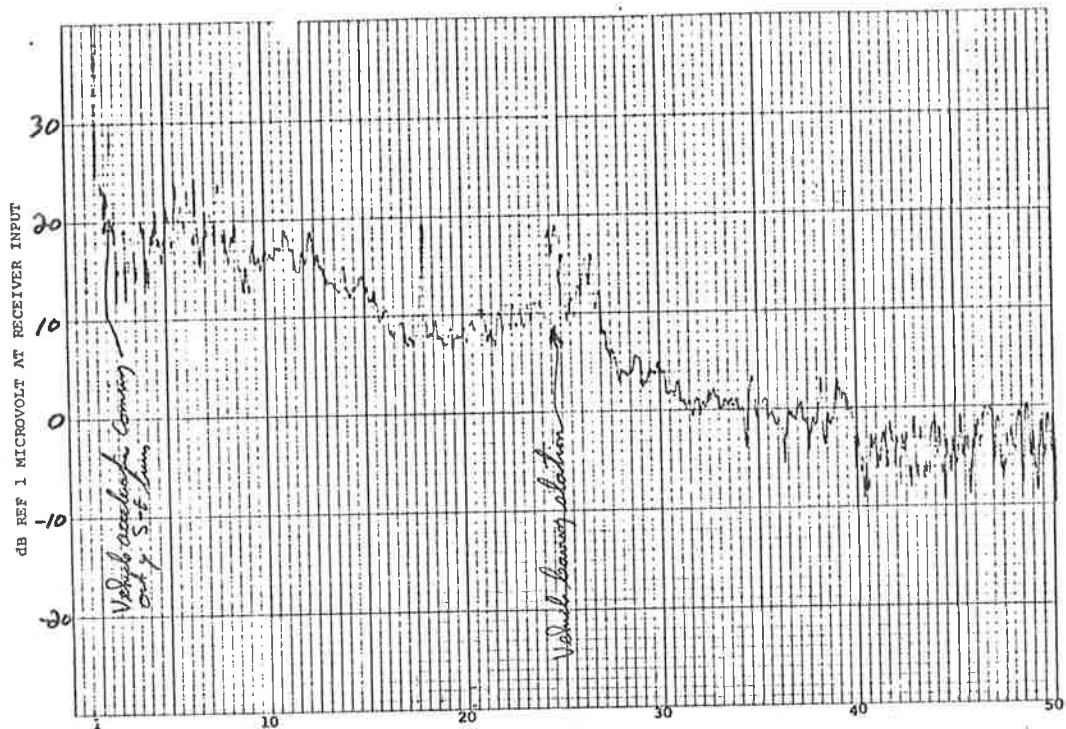


TEST NO. 330  
TEST SPECIMEN 2066

TEST TYPE MSR N/S  
TEST EQUIP. FMC-10

BANDWIDTH 50 Hz  
DATE 7-28-72

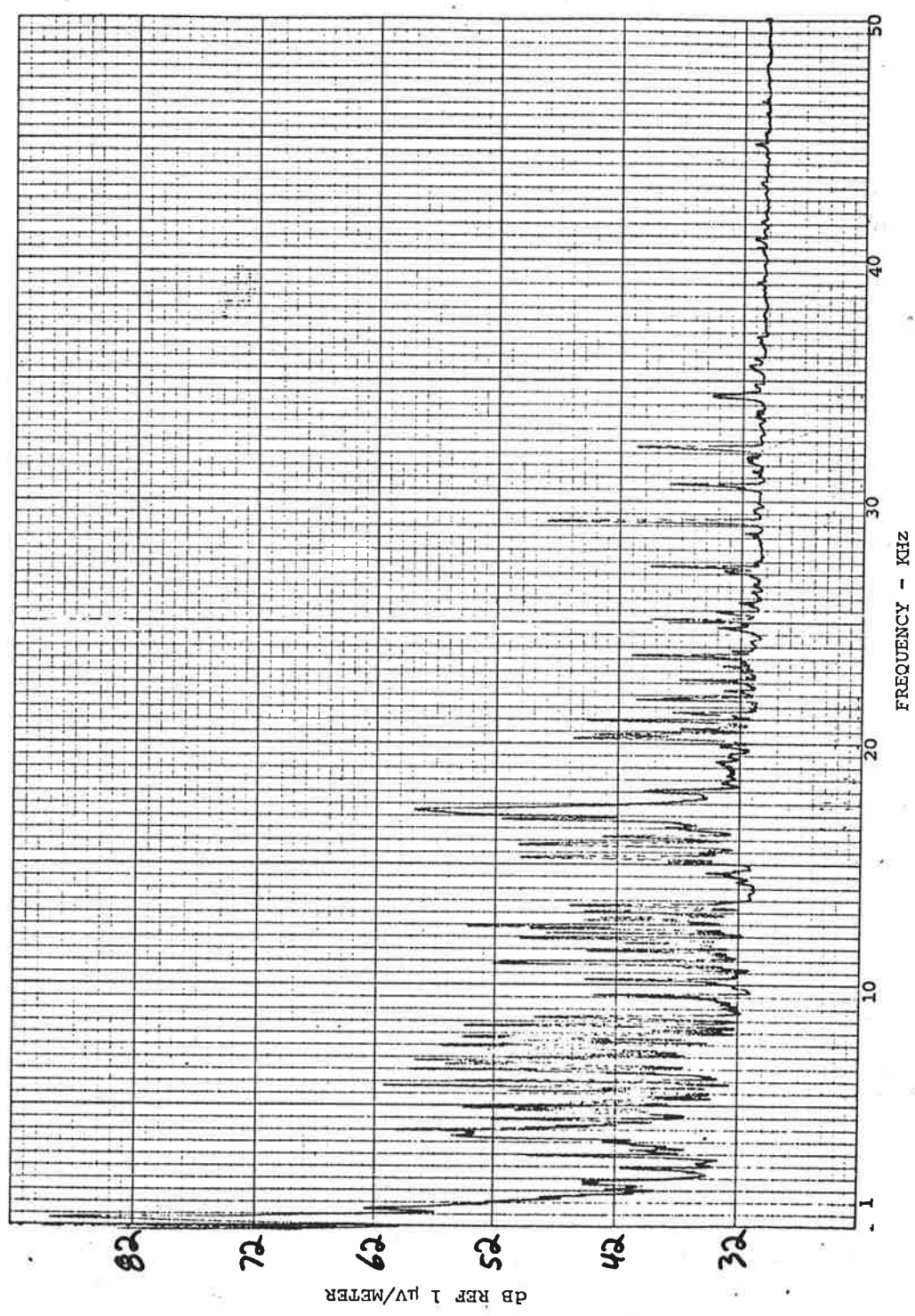
1542  
588

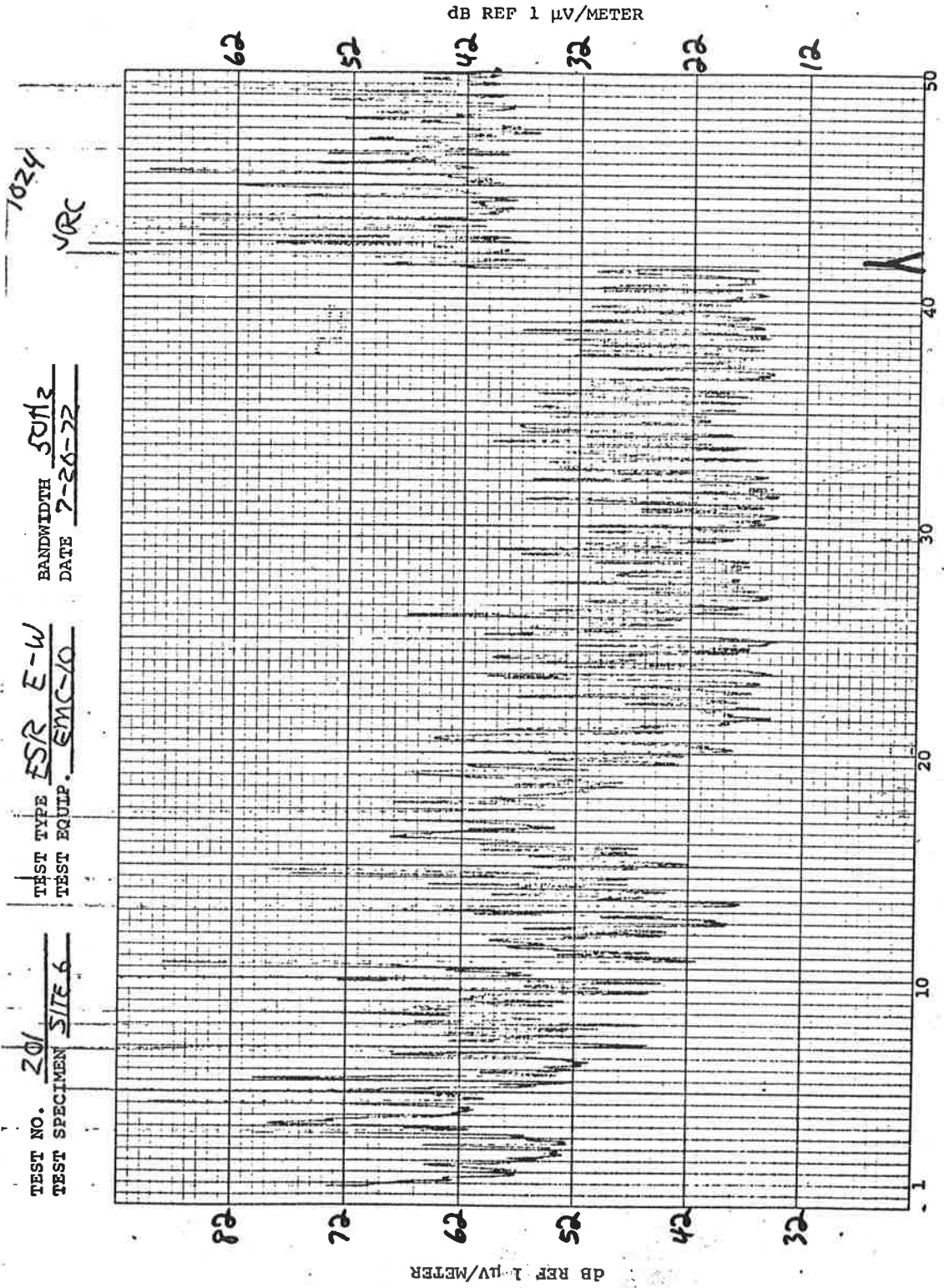


JRC  
10/5

TEST NO. 200 BANDWIDTH 50 Hz  
TEST SPECIMEN SIC 6 DATE 7-26-72

TEST TYPE ESR TEST EQUIP. EMC-10  
E-W





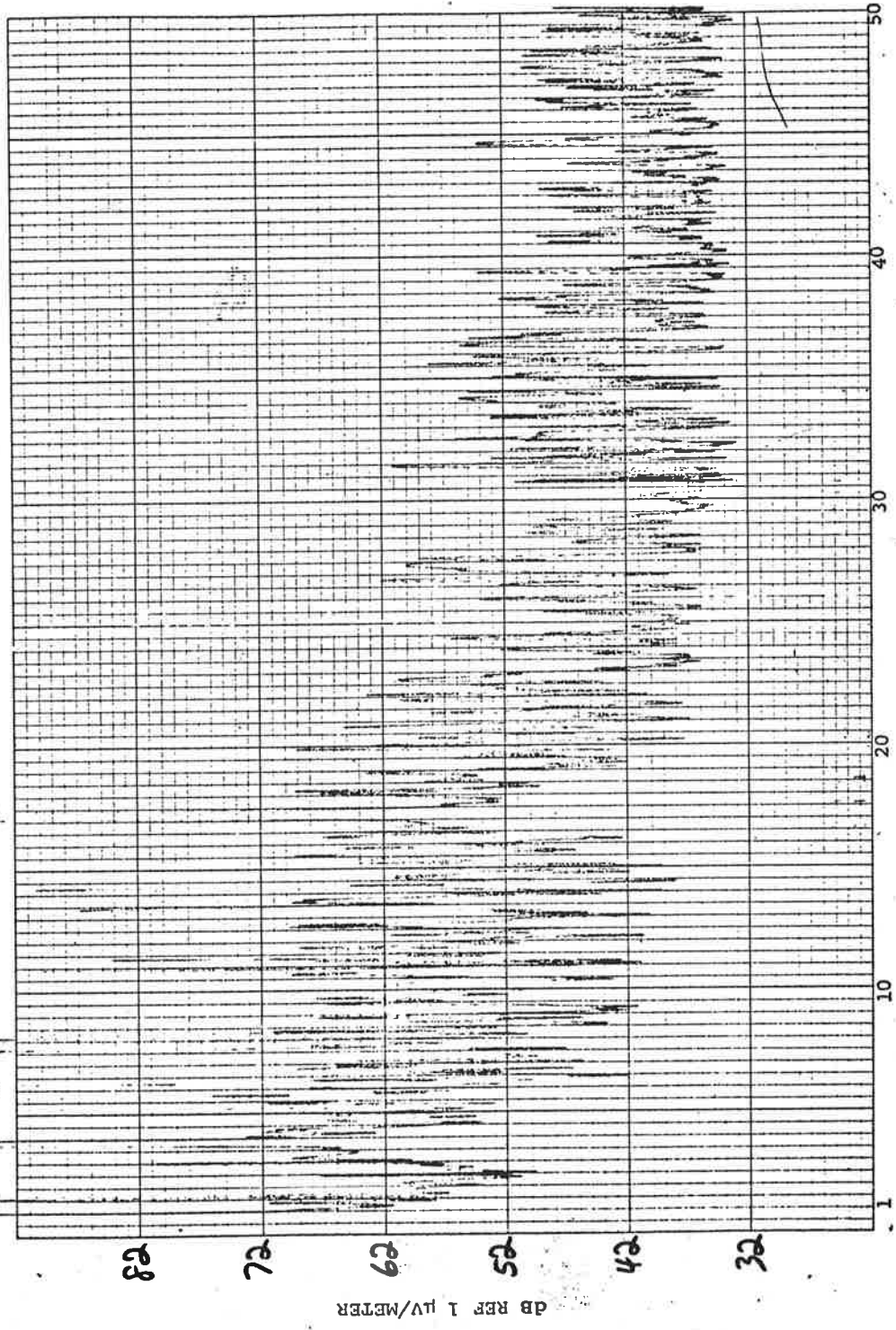


1030  
JRC

BANDWIDTH 50 Hz  
DATE 7-26-77

TEST TYPE ESR EW  
TEST EQUIP. EMC-10

TEST NO. 202  
TEST SPECIMEN BT-6



FREQUENCY - KHZ

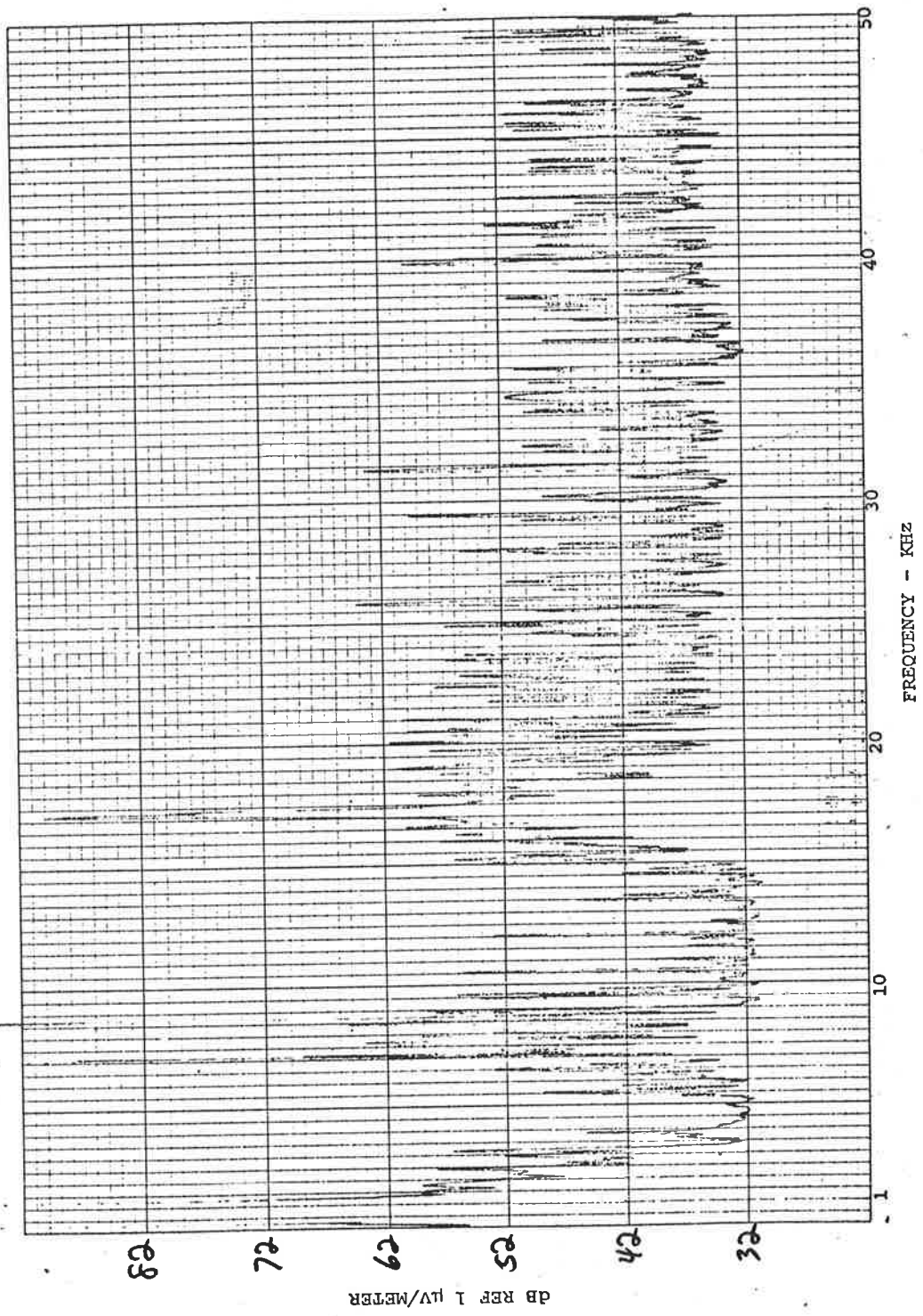
DB REF 1 μV/METER

1003  
JRC

BANDWIDTH 50Hz  
DATE 7-26-72

TEST TYPE ESR N-5  
TEST EQUIP. SMC-10

TEST NO. 198  
TEST SPECIMEN SFE 6

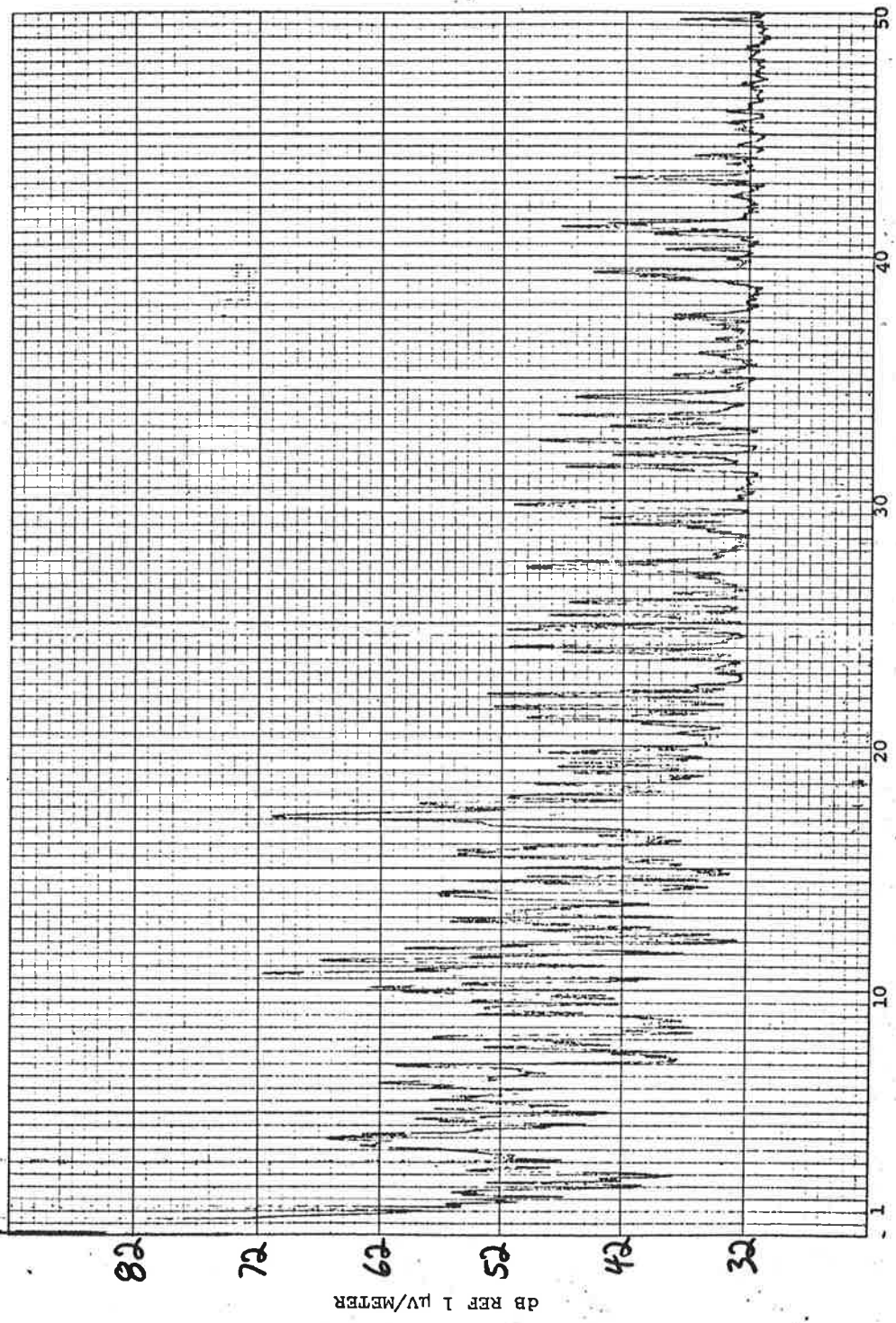


1009  
JRC

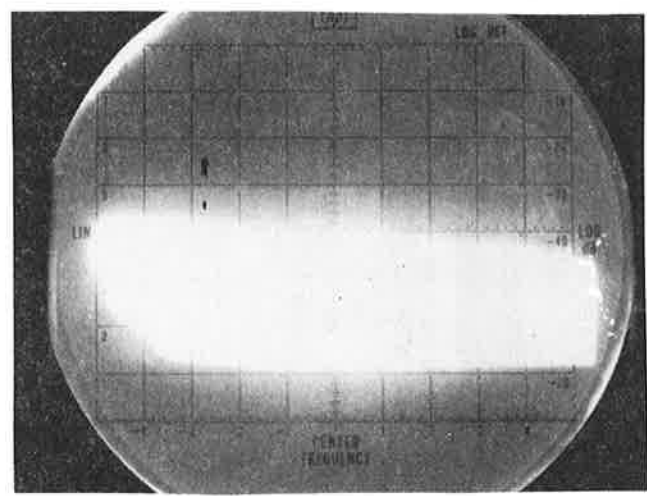
BANDWIDTH 50 Hz  
DATE 7-26-72

TEST TYPE ESR M-S  
TEST EQUIP. EMC-10

TEST NO. 199  
TEST SPECIMEN SITE 4



LOCATION: SITE 6 TYPE TEST ESR DATE 7-26-72

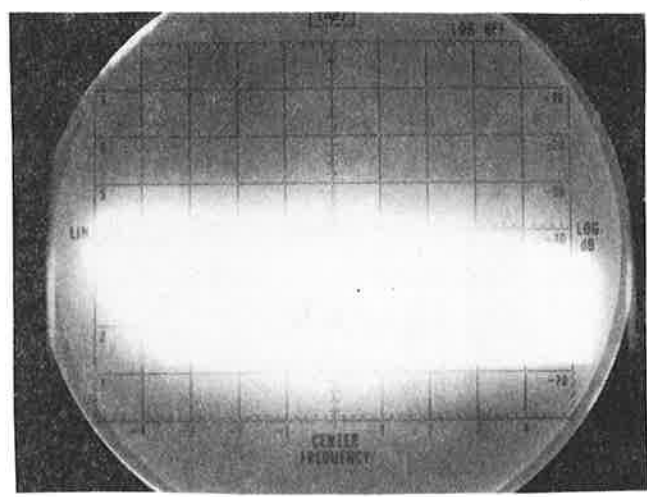


123  
103  
83  
63  
43

TEST 196  
TIME 0925

50 FREQ. 75 KHz 100

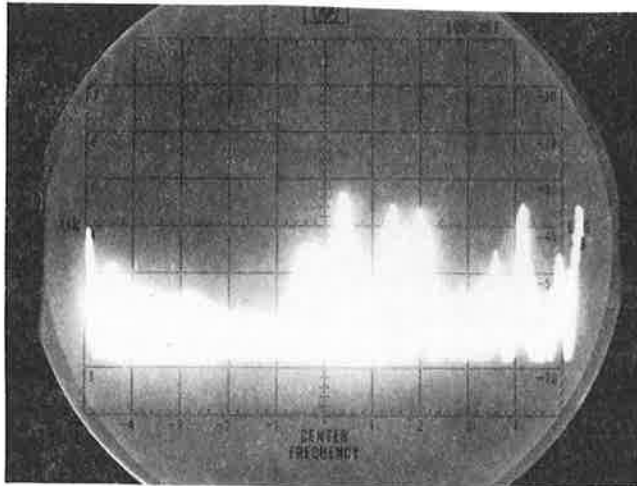
FREQ. SCAN: 5 KHz/Div.  
Bandwidth: 10 KHz



123  
103  
83  
63  
43

TEST 196  
TIME 0926

LOCATION: SITE 6 TYPE TEST ESR DATE 7-26-72



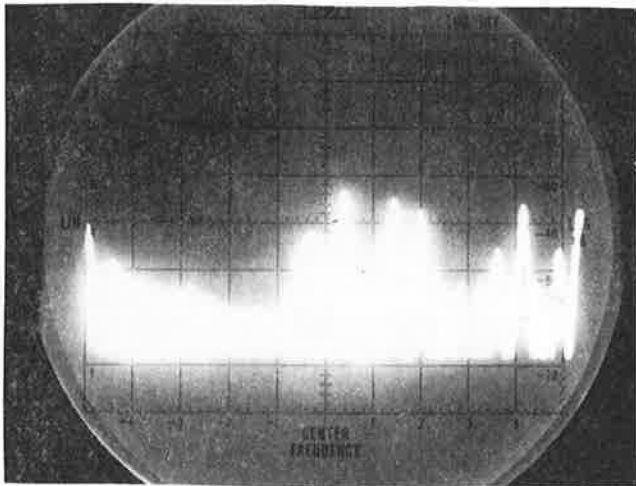
123  
103  
83  
63  
43

TEST 195  
TIME 0919

0.1 FREQ. 0.6 MHz 1.1

FREQ. SCAN: 0.1 MHz/Div.

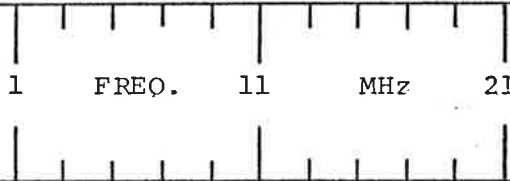
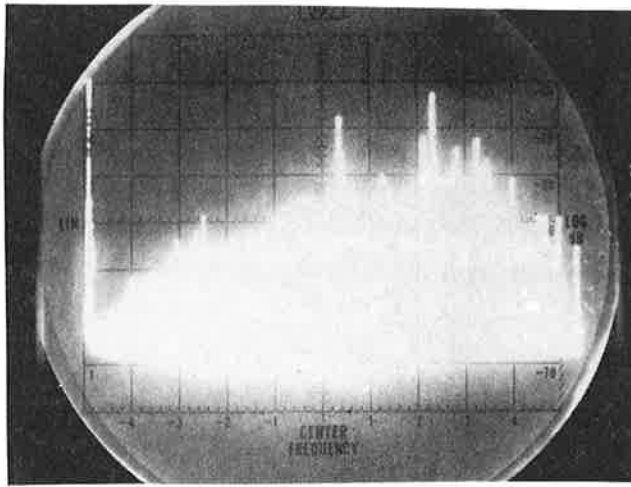
Bandwidth: 10 KHz



123  
103  
83  
63  
43

TEST 195  
TIME 0920

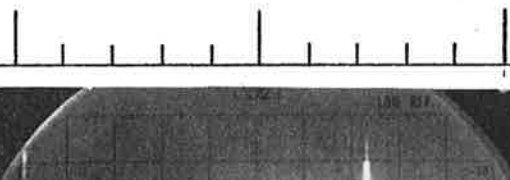
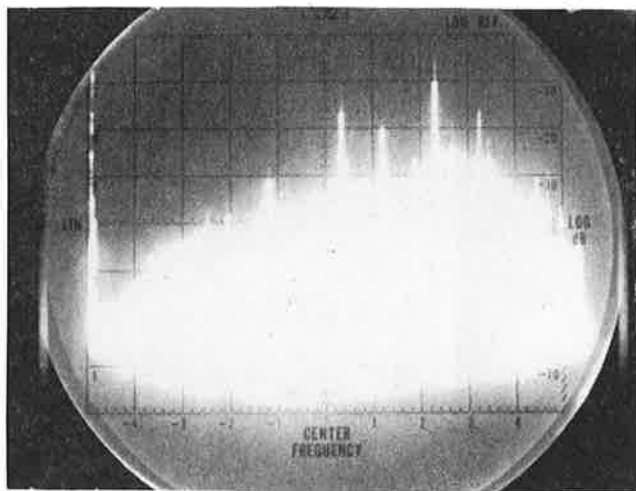
LOCATION: SITE 6 TYPE TEST ESR DATE 7-26-72



123  
103  
83  
63  
43

TEST 194  
TIME 0910

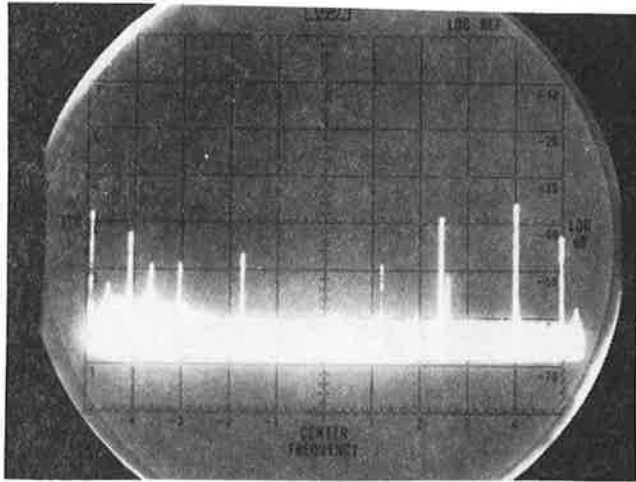
FREQ. SCAN: 2MHz/Div.  
Bandwidth: 10 KHz



123  
103  
83  
63  
43

TEST 194  
TIME 0911

LOCATION: SITE 6 TYPE TEST ESR E/W DATE 7-26-72



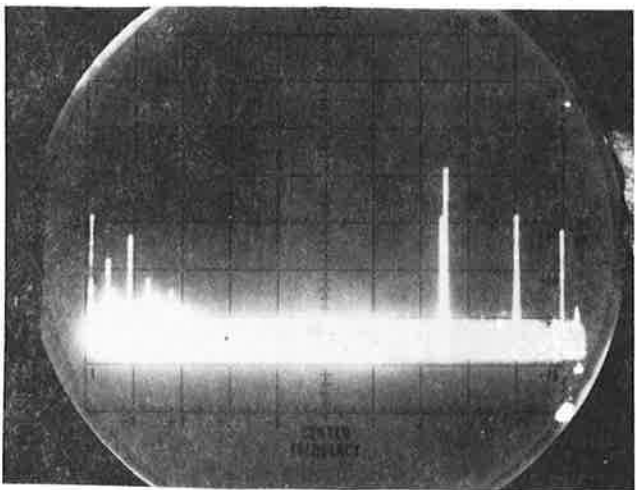
dB REF 1  $\mu$ V/METER/MHZ  
115  
95  
75  
55  
35

TEST 193  
TIME 0900

10 FREQ. 35 MHz 60

FREQ. SCAN: 5MHz/Div.

Bandwidth: 10 KHz

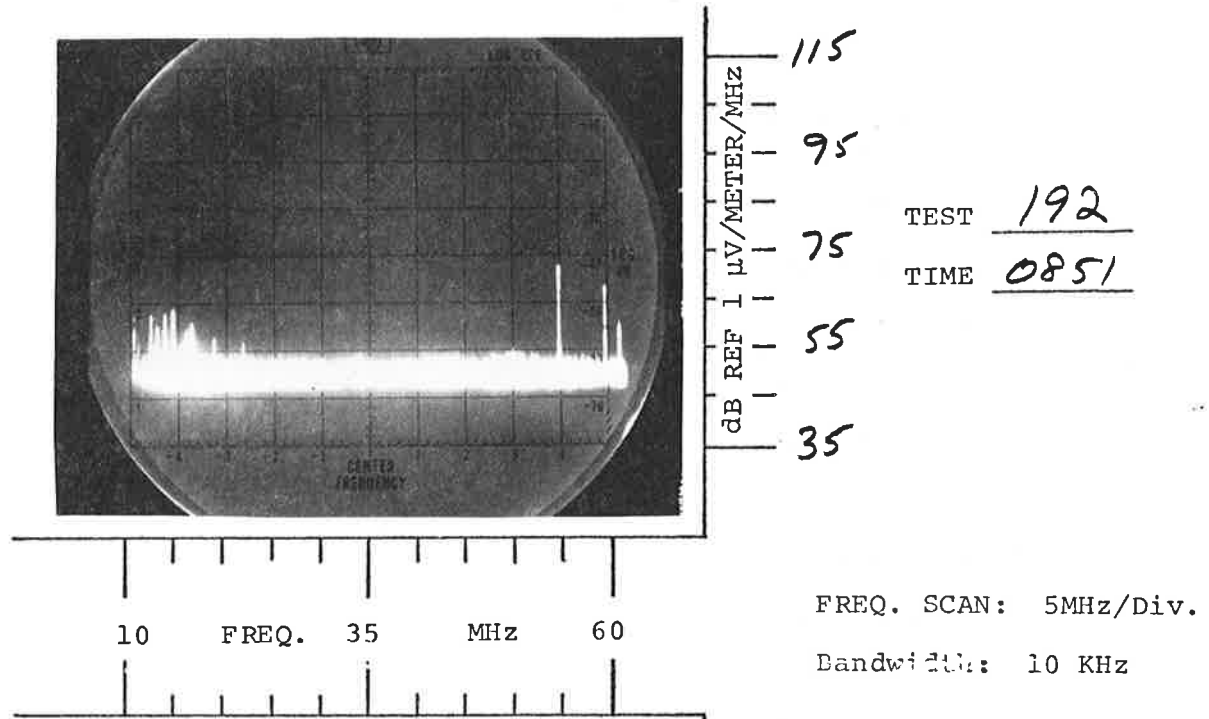


dB REF 1  $\mu$ V/METER/MHZ  
115  
95  
75  
55  
35

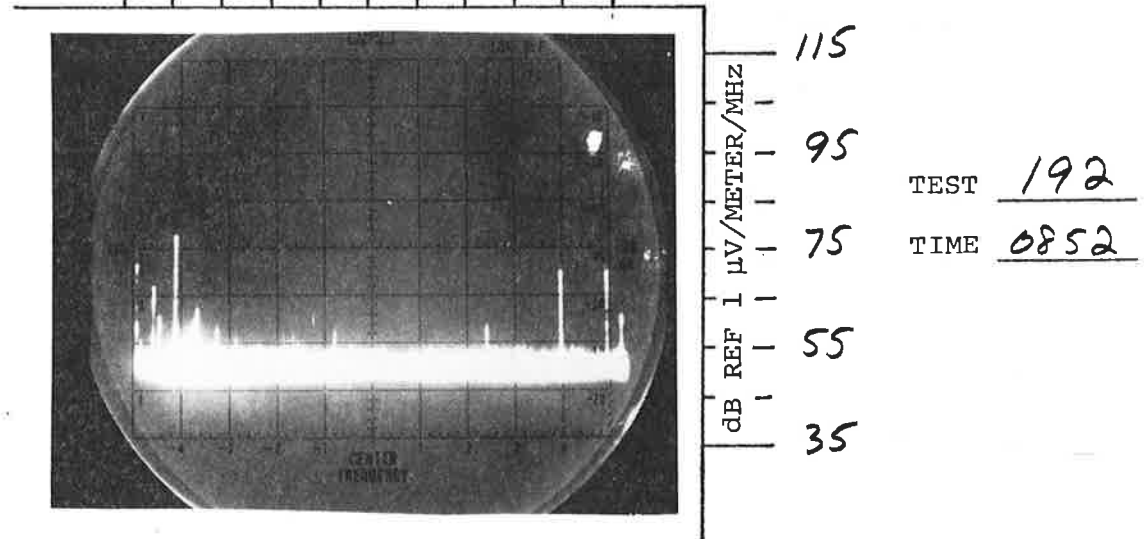
TEST 193  
TIME 0901



LOCATION: SITE 6 TYPE TEST ESR N/S DATE 7-26-72



TEST 192  
TIME 0851



TEST 192  
TIME 0852

MONOCAB

JULY 26, 1972

8:00 Main guideway power on with both vehicles running in automatic

8:15 Both vehicles stopped

8:30 Both vehicles running in automatic

8:40 Door problem at gate 2. Reinitiated system

9:15 Vehicles both stopped

9:24 Both vehicles running in automatic

10:00 Both vehicles stopped

10:05 Both vehicles running in automatic

10:15 Both vehicles stopped

10:26 Both vehicles running in automatic

10:52 Both vehicles coming in under manual

10:55 Hold for instrumentation set-up

11:00 Both vehicles running in automatic

11:25 - 11:29 System reinitialization

11:29 Both vehicles running in automatic

12:04 Both vehicles down

12:10 Reloaded and running

12:50 Stopped for end of test

MONOCAB

July 28, 1972

2:54 Both vehicles running automatic.  
3:50 Both vehicles down (loss of communications).  
4:00 Both vehicles running automatic.  
4:15 System shut down.

